SOME ASPECTS OF POPULATION DYNAMICS OF THE RAILBELT MOOSE POPULATIONS ALASKA

SOME ASPECTS OF POPULATION DYNAMICS OF THE RAILBELT MOOSE POPULATIONS ALASKA

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By

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PREFACE

Although the North American Moose has been a prized trophy and meat animal for years, many elements of its basic biology have not been learned. Recently, studies designed to provide the knowledge necessary for the proper utilization of the moose have been inaugurated in various portions of North America. In this paper the author presents the results of one such study made in south central Alaska from 1956 to 1958.

The author began this study in January, 1956, as a research project sponsored by the Alaska Railroad and by Federal Aid in Wildlife Restoration. The project had the following basic goals: 1) to devise a means of alleviating the moose versus railroad conflicts, and 2) to gather data pertinent to proper moose management techniques in the study area. Only the latter phase of the project is reported on here.

The author greatly appreciates the financial assistance of the Alaska Railroad and the United States Fish and Wildlife Service, and thanks the United States Fish and Wildlife Service for permission to use both data gathered by him while an employee and also some gathered by other personnel.

During the study the author also received much valuable and necessary help from many persons. He would like to extend his appreciation to: Robert F. Scott, Leader of the Alaska Cooperative Wildlife Research Unit (formerly Supervisor of Wildlife Restoration, Alaska), for conceiving the project, for guidance in planning, for many helpful suggestions during the data collecting and data compiling phases of the project, for financial aid, and for use of equipment.

Dr. John L. Buckley, Assistant Chief, Branch of Wildlife Research, Bureau of Sport Fisheries and Wildlife, United States Fish and Wildlife Service, Washington, D. C. (formerly Leader of the Cooperative Wildlife Research Unit, College, Alaska), for graciously allowing the author to change his thesis problem from a mink study which had been inaugurated, for kind and sympathetic consideration following a tragic boating accident which took the life of an assistant, John Isaac, and for helpful suggestions on the present thesis.

Dr. Frederick C. Dean, Head of Wildlife Management Department, for critical comments on the thesis.

Dr. Brina Kessel, Acting Head of Department of Biological Sciences, for her most careful reading of this thesis and many helpful suggestions.

Sam Harbo, former University of Alaska graduate student, now with the Alaska Department of Fish and Game, Juneau, for continuing and completing the mink project which the author had started.

Ronald O. Skoog, Wildlife Management Biologist, United States Fish and Wildlife Service, for many hours of discussion--often referred to as "arguments" by innocent bystanders--about moose and other interesting topics which frequently helped resolve thesis problems.

Dustin L. Sloan, field assistant during 1957, for collecting and processing many "highly aromatic" moose specimens.

The personnel of the Anchorage Game Management Office, United States Fish and Wildlife Service, for collecting much valuable moose data.

The Alaska Railroad section crews of Willow, Caswell, Sunshine, and Talkeetna for extending the hospitality of their homes and sharing many a frigid ride on well ventilated gas cars.

Lastly and certainly the one who should perhaps receive the greatest expression of appreciation, my wife, Frances G. Rausch, for the long hours spent typing, re-typing, drawing, and especially for her patient (?) insistence that this thesis be completed in 1959.

To all of these people, the author gratefully acknowledges his thanks.

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ABSTRACT

SOME ASPECTS OF POPULATION DYNAMICS OF THE RAILBELT MOOSE POPULATIONS

Moose in the Lower Susitna Valley constitute one of Alaska's most valuable big game resources. These moose were studied from January, 1956, to June, 1958.

Male moose reach sexual maturity at 16 to 18 months; females usually at 28 to 30 months, although a few breed at 16 to 18 months. Rut extends from early September through early November. Conception probably peaks in early October. All moose (over two years old) examined were fertile. Ninety-four per cent of Age Class II and older females were pregnant.

Sex and age data on 476 moose (fetuses to old-age) were obtained from railroad, highway, and illegal kills. Sex ratios of fetuses and calves indicate a 100:100 sex ratio. Sex ratios of animals older than calves are distorted by hunting, but natural mortality of lightly hunted adults is apparently greater in males. Age structure of three local populations differs somewhat--possibly due to environment. Calf mortality of 30 to 70 per cent by October or November may be normal for the populations studied. Hunting, accidents, and severe winters are believed the principal mortality factors beyond six months.

Weights and measurements of 83 moose are presented. About 90 per cent of the total skeletal growth is completed by 17 to 18 months.

Weight increase continues several years.

INTRODUCTION

The moose populations which inhabit the Lower Susitna Valley (Figures 1 and 2), along with those on the Kenai Peninsula constitute Alaska's most valuable, abundant and accessible moose populations. Chatelain (1951) discussed the winter range problems, population growth, and relatively brief history of the Lower Susitna Valley herds. He stated that prior to 1930 moose were scarce throughout these areas. By the mid-forties moose were abundant, however, particularly in the choice winter browse areas along the Alaska Railroad between Houston (Mile Post 172) and Talkeetna (Mile Post 228); by 1948 they were very abundant in the Matanuska Valley.

The moose, which tend to concentrate in the choice browse areas along or adjacent to the railroad right-of-way have created two major problems: one involves moose obstructing the railroad right-of-way; the other involves the management of these valuable moose populations.

In addition to concentrating in choice browse areas along the railroad, moose also use the plowed roadbed as a route of travel, particularly during periods of deep snow cover. This practice frequently results in moose-train accidents. During winters having unusually deep accumulations of snow, as many as two hundred moose have been killed on the 56-mile segment of the railroad between Houston and Talkeetna. This area, roughly 15 per cent of the total railroad mileage, accounts for 75 per cent of the annual railroad-moose fatalities. These accidents

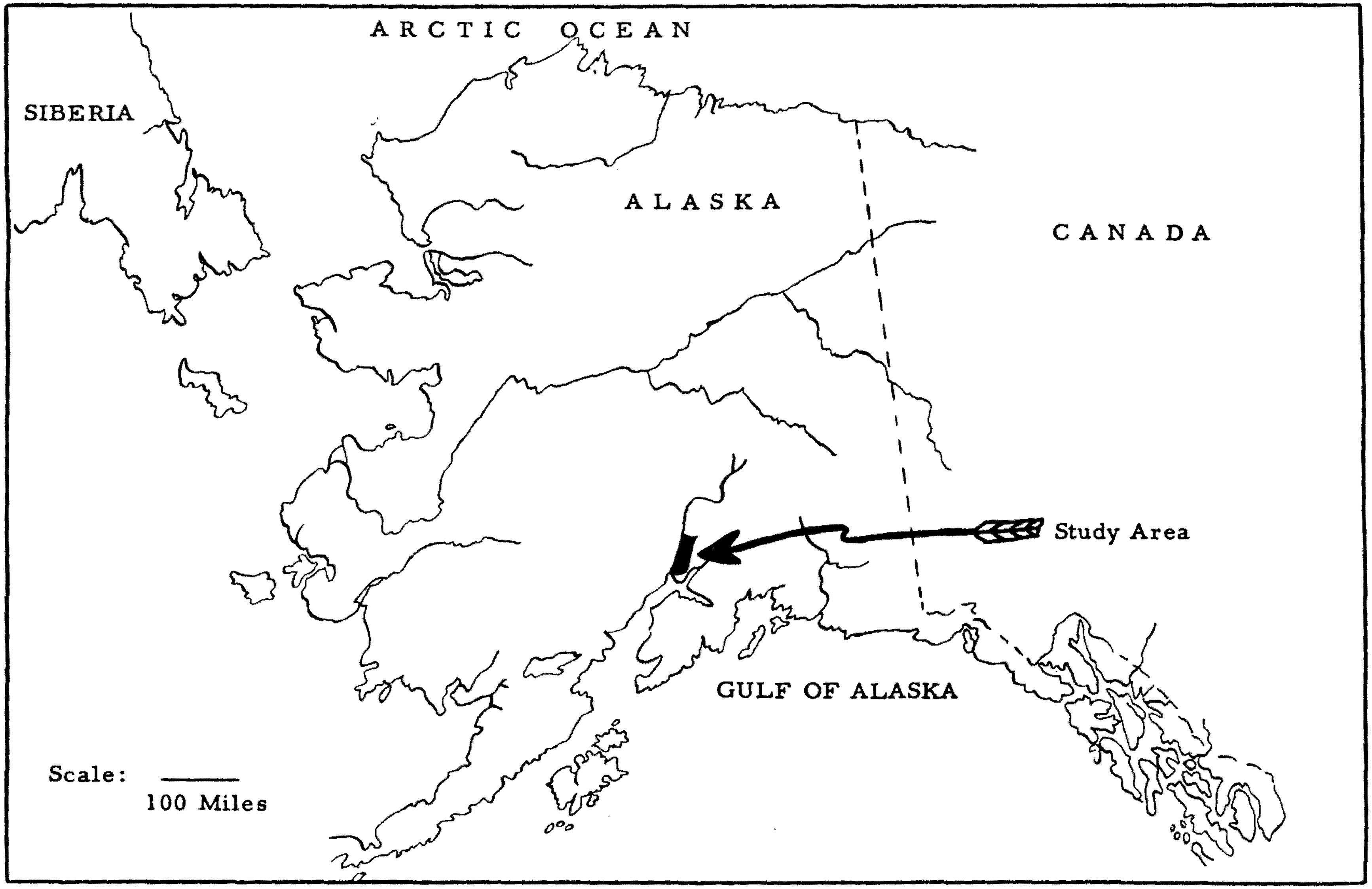

Figure 1. Location of study area.

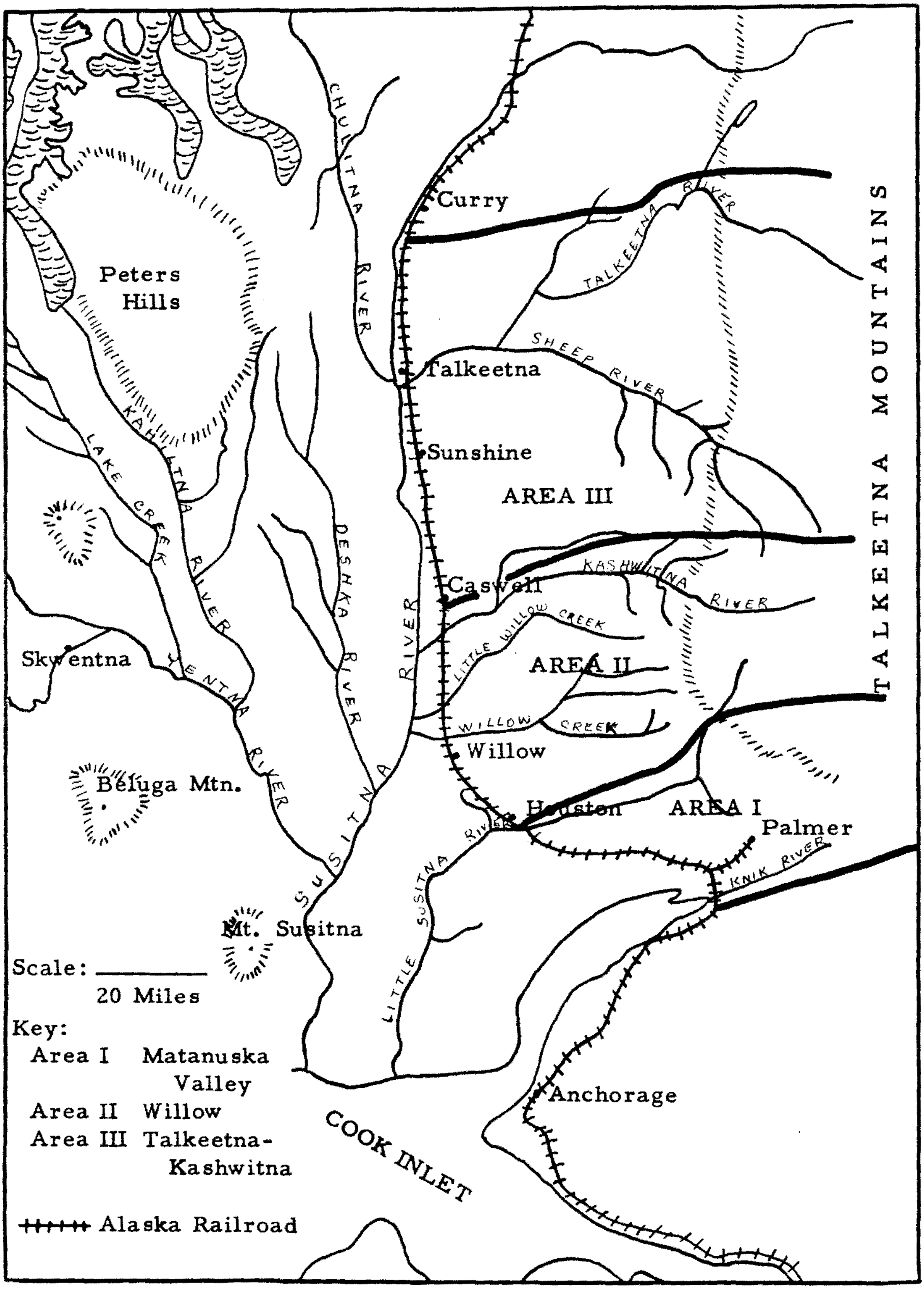

Figure 2. Map of Lower Susitna Valley showing location of three Railbelt moose populations.

represent an undesirable destruction of a valuable resource and an expensive additional operating hazard to the railroad. Moose have caused train derailments which have resulted in the destruction of equipment worth many thousands of dollars.

In December, 1955, the Alaska Railroad and the United States Fish and Wildlife Service jointly sponsored a study in an effort to find some means of alleviating, and if possible ending, the moose versus train conflicts. This study was conducted by the author and was continued during the winters of 1956 and 1957. A completion report appears in Vol. 12, Federal Aid in Wildlife Restoration, Project W-3-R-12, Work Plan A, Job No. 4.

Concurrent with the above study and in the same area a study of moose population dynamics was inaugurated and it is continuing. The purpose of this project was to obtain data pertinent to proper management of the problem moose populations inhabiting the railbelt areas, and to gain a better understanding of moose population dynamics. Data pertinent to the following aspects of moose population dynamics are presented: reproduction, sex and age distribution, survival, weights and measurements, and growth.

REPRODUCTION

Quantitative data illustrating the age of sexual maturity, period of rut, and fertility for the moose (Alces alces Linnaeus) of North America, and particularly for the Alaskan subspecies (A. a. gigas Miller), are extremely limited or totally lacking. The data presented here represent some of the results obtained from examining moose killed accidentally, illegally, or by hunters, and from aerial and ground observations made of the moose populations inhabiting the Matanuska Valley and Railbelt areas. These data were collected between January, 1956, and June, 1958.

Age of Sexual Maturity.

Most workers have not considered yearling (12-24 months) males important contributors to the reproductive segment of moose populations. Skuncke (1949) indicates that in Sweden male moose may be capable of fertilizing cows when two and one-fourth years old, but that the larger bulls seldom allow them the opportunity. Peterson (1955) mentions that the age of sexual maturity in male moose is not definitely known, but that some authorities believe bulls are capable of breeding at 16 months.

Observations of moose rutting behavior by the writer have been limited to the periods immediately before and after the main rut, periods when the "harem-like" groups consist of both adult and yearling males seemingly peacefully intermingled with the accompanying cows and calves.

Yearling male moose are capable of and in all probability do fertilize cow moose, and may become an important factor in the reproduction of a heavily hunted moose population, such as that of the Matanuska Valley. Here, hunting has greatly reduced the male segment of the population, and aerial sex and age composition counts reveal that the remaining males are approximately 90 per cent yearlings: groups of 10 to 30 animals consisting of cows, calves, and one to four young bulls were observed in late October 1957. One instance of what appeared to be successful copulation by a yearling bull with an adult cow was observed.

Further confirmation that yearling male moose are capable of fertilizing cows is provided by Dr. J. L. Buckley, then, Leader, Cooperative Research Unit, College, Alaska, who reports that examination of the epididymal contents of three yearling male moose collected near Fairbanks, Alaska, on September 7, 12, and 17, 1953, respectively, revealed the presence of spermatozoa. Microscopic examination of the epididymis contents of 17 yearling moose killed in August, September, and November, 1957, in the Matanuska Valley yielded similar findings (Table 1).

Information, in the literature, regarding the age at which female moose first breed is seemingly as speculative as that on the male moose. Peterson (1955), citing Lonnberg (1923) and Skuncke (1949), postulates that a few females probably breed at 16 to 18 months, but that most breed at 28 to 30 months. Skuncke states that yearling females

TABLE 1. BREEDING CONDITION OF BULL MOOSE IN SOUTH CENTRAL ALASKA AS INDICATED BY THE PRESENCE OF SPERMATOZOA IN THE EPIDIDYMIS

Collection Date	Spermatozoa Present	Age Class	Accession No. R. A. R.
December 20, 1956	? *	Calf	None
August 22, 1957	Yes	I	892
August 22, 1957	Yes	I	636
August 22, 1957	Yes	I	897
August 22, 1957	Yes	I	895
August 24, 1957	Yes	I	615
August 25, 1957	Yes	I	558
August 25, 1957	Yes	I	832
September 1, 1957	Yes	I	532
September 2, 1957	Yes	I	519
September 2, 1957	Yes	I	917
September 8, 1957	Yes	I	923
September 8, 1957	Yes	I	822
September 15, 1957	Yes	I	668
September 18, 1957	Yes	I	588
November 2, 1957	Yes	?	793
November 3, 1957	Yes	I	800
November 23, 1957	Yes	I	778
December 8, 1957	Yes	IV	None
March 31, 1957	Yes**	I	444
January 8, 1958	Yes**	VIII	965

* A very few developing spermatozoa in testis and what appeared to be decomposing spermatozoa in the epididymis.

** Very few spermatozoa--no spermatozoa with tails observed.

occasionally conceive and that most females breed first as two-year-olds, but that frequently they do not breed until they are three. Ritcey and Edwards (1958) found no pregnant yearlings in a sample of 15 uteri collected from yearlings at Wells Gray Park, British Columbia, during the period when moose normally are pregnant. They further express the belief that no females of this population breed prior to their third fall.

The uteri and ovaries of 31 moose, Age Class Calf to Class III, have been examined by the author. In seven calves there was no instance of ovulation or pregnancy. Of nine yearlings examined, six were collected during the winter months and three during the late fall. One, a very large yearling, collected in Spenard, Alaska, on March 19, 1957, was pregnant. The ovaries of a yearling collected on November 10, 1957, showed a corpus luteum, partially lutenized, but no fetus was found. The corpus luteum may have represented an ovulation which did not result in pregnancy, or it is possible that the embryo had not attached to the uterine wall and was lost during examination. No indications of ovulation or pregnancy were observed in seven other yearlings examined. Examination of the uteri and/or ovaries from 17 Age Class II and III individuals collected between November and May showed that only two were not pregnant. Ovarian analysis in this age group revealed an average of 1.4 corpora albicantia of corpora lutea of pregnancy per pair of ovaries (Table 2). This suggests that both two- and three-year-old moose are represented in this sample.

TABLE 2. CORPORA ALBICANTIA INCIDENCE IN OVARIES COLLECTED FROM SOUTH CENTRAL ALASKA MOOSE

Age Class	No. Pairs Ovaries	No. Individual Ovaries	No. Corpora Albicantia in Paired Ovaries	No. Corpora Albicantia in Individual Ovaries	Total Corpora Albicantia	Total Ovaries	Corpora Albicantia Range	Ave. No. Corpora Albicantia per Pair of Ovaries	Ave. No. Corpora Albicantia per Ovary
I	6	2	0	0	0	14	0-0	0	0
II & III	5	1	7	0	7	11	0-2	1.4	.64
IV & V	6	2	20	5	25	14	0-5	3.3	1.78
VI & VII	8	-	53	-	53	16	0-7	6.6	3.3
VIII & IX	6	-	58	-	58	12	2-7	9.6	4.8
Totals	31	5	138	5	143	67	0-7	4.4	2.1

These data indicate that no calves of the year breed or ovulate; that a few yearling females do breed, although the data are too limited to tell how many; and that approximately 90 per cent of two- and three-year-old females are pregnant, indicating that most female moose on this range breed first at 28 to 30 months.

Period of Rut.

The period of rut or breeding of moose, similar to many other facets of its reproductive cycle, is known only in a general sense.

Most authorities agree that rut activities commence in early September and continue through most of October. However, exact dates and true peak of ovulation and conception are not known. Ritcey and Edwards (1958) state that most cows in Wells Gray Park, British Columbia, breed during a ten-day period in late September, and that four periods of oestrous occur from early September through October. Skuncke (1949) reports that moose in Sweden breed during the first two weeks of October. Specimens or observations representing three phases of the reproductive cycle of the moose populations inhabiting the Matanuska Valley and Railbelt areas were collected in an attempt to more accurately delineate the period of sexual activity. The data obtained include the following:

A. Weights of testes.

B. Parturition.

C. Embryo and fetus growth.

A. Weights of Testes. Testes of certain cervids reflect the period of sexual activity through increased size and weight. Cheatum (1946) reported that volumetric determinations of white-tailed deer testes indicated a fall peak in size. He presented data which show that the peak of testes size, which occurs in November in that area, coincides with the peak of conception.

One hundred and sixty-seven moose testes were collected during the winter of 1956-57 and the fall and winter of 1957-58. The testes were preserved in 10 per cent formalin. Standardization of the portions of the testes used for weight and volumetric determinations was obtained by dissecting the testes free from the tunica vaginalis, and by severing the vas efferentia from the testes. This process removed all extra tissue from the testes, particularly fat deposits, which were considerable on testes collected in August and September. The testes were then weighed to the nearest gram and volumetric measurements, using the water displacement technique, were taken to the nearest cubic centimeter. In this report only the weight measurements are used.

Male moose vary greatly in body size, both with respect to age and individual variation (see Weights and Measurements). Body size and testis size are probably proportional. The greatest variation in body size and testis size occurs within Age Class I; because of this variation, Class I bulls are considered separately. If a larger sample of testes from known-age animals were available, division according to age classes might reduce the great range in testis weights and give some indication as to which age group first reaches a peak of breeding condition, if such a difference exists.

The weights of 80 testes from yearlings clearly indicate a weight increase from August 20 to September 20, a definite decrease in weight is not apparent until December and succeeding months. The sample of testes from November, however, is small and in view of the great size variations within this age class it is possible that this sample is not representative.

The curve, established from the weights of 87 testes collected from moose older than Class I and averaged by periods, is illustrated in Figure 3. Again, the range in weight is great (Table 3). The points for the generalized curve were obtained by averaging the testis weights by five- and ten-day periods from August 20 to September 20 and from November 1 to 30. Testes collected later were averaged by two week periods. These data indicate a definite weight increase from August 20 through September 20 and a corresponding decrease through November and December with a possibly constant weight from January through March.

If the curve in Figure 3 accurately portrays moose testis development, the peak of male breeding condition occurs about October 1. This period coincides with a closed hunting season, so unfortunately no testis weights are available for this period.

B. Parturition. Aerial counts of moose inhabiting favored calving

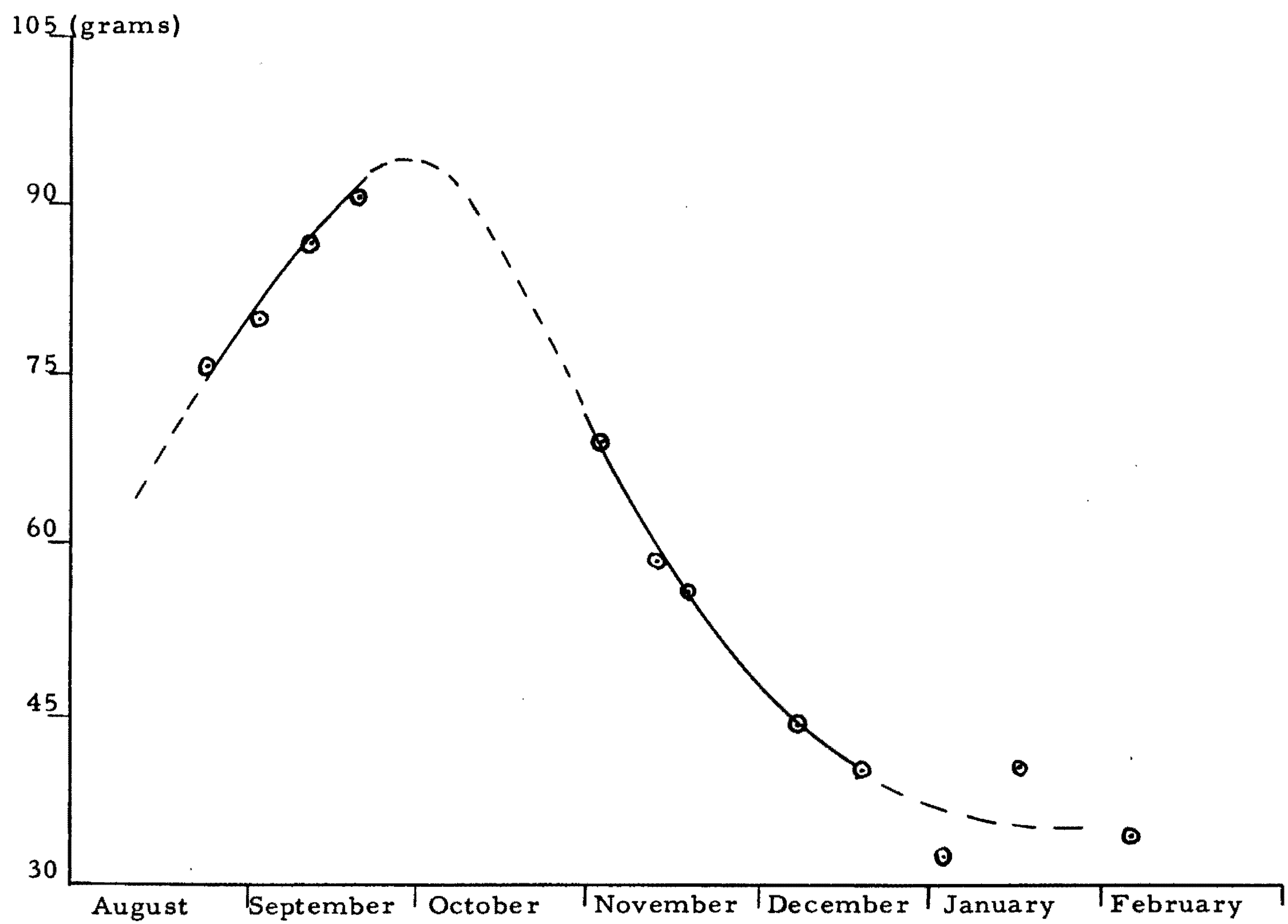

Figure 3. The average weights of 87 testes collected from adult moose in south central Alaska.

TABLE 3. THE AVERAGE AND RANGE IN WEIGHT OF 87 TESTES FROM ADULT MOOSE COLLECTED IN SOUTH CENTRAL ALASKA

Date	No. Testes	Ave. Weight (Grams)	Range
August 20-25	27	76.0	52-92
August 30-September 7	8	79.4	59-109
September 8-14	9	86.3	63-110
September 15-20	11	90.0	68-120
November 1-6	1	69.0	69-69
November 7-13	3	58.3	56-62
November 14-20	4	57.2	46-66
December 8	2	44.5	42-47
December 18	2	40.0	35-45
January 1-4	4	32.7	32-34
January 8-31	6	42.3	34-56
February 1-14	10	35.4	28-43
Total	87		

areas in the Matanuska Valley and along the Railbelt were made between May 20 and June 4, 1957. These counts are summarized in Table 4.

In the following discussion and in Table 4 the term parturition:cow ratio is used to express the progress of calving, and each birth or parturition, whether resulting in one, two or three calves, is considered one instance of pregnancy. Calving was in progress by May 20 and the counts indicated a ratio of 14 parturitions per 100 cows. The ratios on succeeding counts were 26, 54, and 52 per 100, respectively.

The observed parturition:cow ratios are believed to underestimate considerably the true values, because of certain behavorial traits displayed by cow moose, and because of certain variables seemingly inherent to aerial counting. Cows about to give birth and those with newborn calves generally frequent lowland areas. The lowlands are generally swampy and frequently are covered with 8 to 20 inches of water in the spring of the year. The overall vegetation varies greatly, but in general gives the impression of a patchwork of spruce-covered islands with heath, sedge, and sedge-bog openings, and dense borders of alder and willow. The calves are frequently hidden in the alders or on the spruce islands and are also very difficult to see in the heath or sedge openings if they are lying down. Cow moose normally exhibit no definite response pattern to airplanes. Most cows with calves, however, either run to the calf or face in the direction of the calf. When the cow refuses to run to the calf or if the calf remains quiet, the observer frequently is unable to decide definitely if a calf is present. The

TABLE 4. PROGRESSION OF MOOSE CALVING AS REVEALED BY AERIAL CALF:COW COUNTS IN THE LOWER SUSITNA VALLEY

Date	Female Without Calf	Female With One Calf	Female With Two Calves	Observed Parturition: Cow Ratio	Estimated Parturition: Cow Ratio
May 20, 1957	57	7	1	12:100	12:100
May 24, 1957	69	21	3	26:100	53:100
May 29, 1957	28	27	6	54:100	69:100
June 4, 1957	29	25	6	52:100	78:100

tendency of some cows to hide their calves may seriously hamper aerial parturition:cow counts. At present it is not known what age group of calves is most frequently hidden, or if a specific age group is involved. The time of day that the counts are made may also influence the distribution and activity of cows, cows with calves, and calves.

The estimated parturition:cow ratios in Table 4 were computed by including, with the actual calf:cow observations, the instances when no calf or calves were observed even though the cow responded to aerial "buzzing" in a manner that indicated a calf was present.

The spring aerial parturition:cow counts, which possess certain previously discussed variables, show that 50 per cent of the cows in the populations counted have calves by late May (Table 4 and Figure 4). Thus, if moose have a gestation period of 240 to 246 days (see Gestation Period), 50 per cent of the cows were bred prior to October 1.

C. Embryo and Fetus Growth. Another indication of conception dates and period of successful breeding has been obtained from the estimated growth curve established from the measurements of 63 unknown-age moose fetuses (Figure 5 and Table 5). In general this treatment is patterned after Armstrong's (1950) work with white-tailed deer. The total length measurement (following the body contours) was used to establish the points for the growth curve, instead of the crown-rump or forehead-rump measurements used by Armstrong. This total length measurement was more reliable on moose because the points

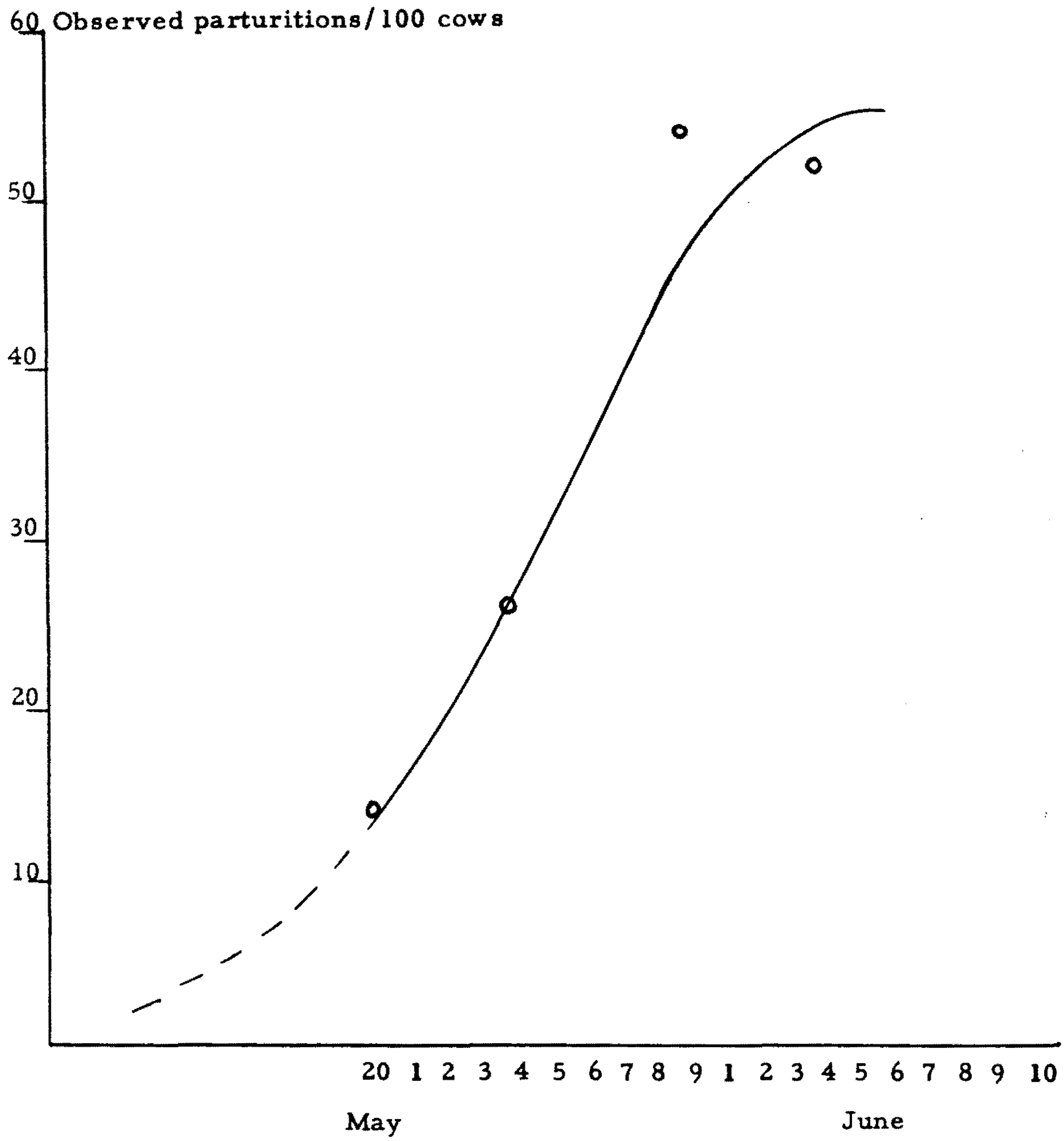

Figure 4. Observed progression of moose calving in south central Alaska, as revealed by aerial surveys.

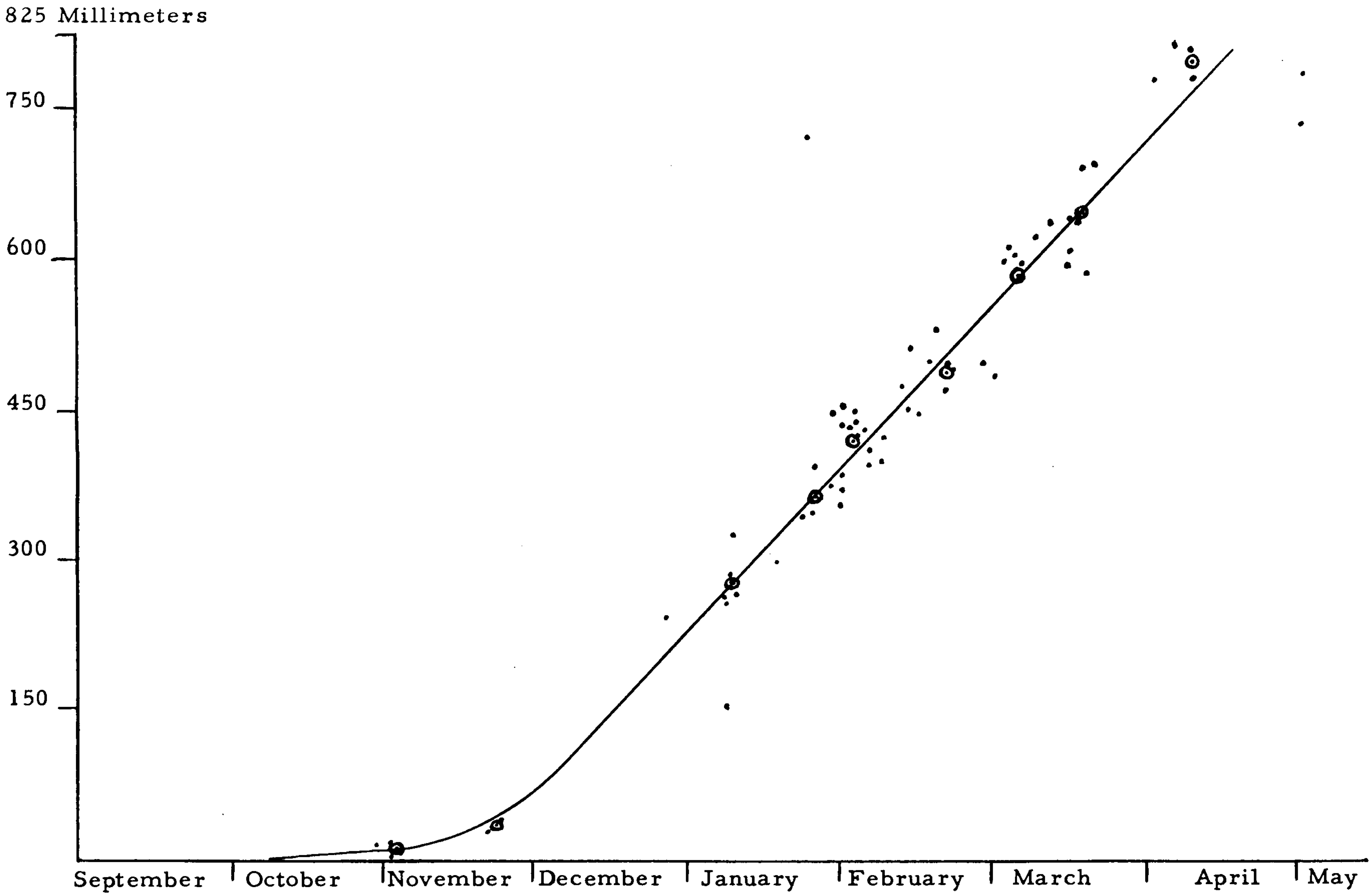

Figure 5. Average growth curve for moose fetuses based on total length measurement of 63 embryos and fetuses.

TABLE 5. WEIGHTS AND MEASUREMENTS OF ALASKAN MOOSE FETUSES

Collection Date	Measurements in millimeters[1] Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.	Zygo. Arch	Weight (Pounds)	Sex	Age Class of Female	Accessio No. R. A. R.
October 31, 1957					20						?[2]	II	677
November 1, 1956					10						?	III-IV	302
November 3, 1957					6						?	XI	676
November 20, 1956					35						?	II	315
November 24, 1956					37						?	VIII	286
December 25, 1956	15	60	80	80	250	135	145	100	32	0-7	M	VI	307
January 6 to 9, 1958	15	60	84	82	267	129	142	107	30		M	IV	976
January 6 to 9, 1958	15	59	84	83	266	127	141	105	34		F	IV	976
January 9, 1958	7	27	42	42	156	87	92	61	24		F	I	979
January 9, 1958	22	87	118	117	328	154	195	132	41		F	Unknown	981
January 8 to 9, 1958	20	79	106	108	294	149	188	123	38		M	V	980
January 10, 1957	19	65	97	95	270	145	170	110	35	0-11	F	IV	422
January 10, 1957	19	65	100	95	275	150	175	130	37	0-12	M	IV	422
January 16, 1957		71				140			34		M		344
January 18, 1956		75	112	95	305				35	0-11	F	III	187. 3
January 23, 1957	23	90	125	120	350	170	200	160	42	1-4	F	IV	330
January 25, 1957	26	100	140	135	355	175	215	150	46	1-9	M	V	435
January 26, 1957	37	115	155	145	400	200	230	190	46	2-0	F	VI	337
January 29, 1957		105		135	350	190	220	180	45	1-12	F	III	355
January 29, 1957	41	125	185	175	455	220	255	200	51	2-11	M	III	336
February 1, 1957	42	125	170	160	460	210	255	205	50	2-9	F	IV	358
February 1, 1957	41	125	165	170	440	215	255	195	50	2-10	F	IV	358
February 1, 1957	33	105	145	145	395	185	220	190	45	1-14	M	V	349
February 1, 1957	33	105	145	135	385	185	210	165	44	1-9	M	VII	347
February 1, 1957	32	105	150	140	375	185	205	180	46	1-9	M	VII	347
February 4, 1957	45	135		170	450	220	250	190	54	2-14	M	III	367

TABLE 5 (Continued)

Collection Date	Measurements in millimeters								Zygo. Arch	Weight (Pounds)	Sex	Age Class of Female	Accession No. R. A. R.
	Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.					
February 4, 1957	38	115	160	155	430	205	250	200	49	2-6	M	Unknown	None
February 4, 1957	42	120	180	170	440	225	250		51	2-13	M	IV	373
February 4, 1957	38	120	160	150	440	210	250	180	49	2-5	M	V	365
February 4, 1957	36	120	165	150	430	205	230	185	50	2-5	M	V	365
February 6, 1957	44	125	175	165	415	220	275	190	54	3-2	F	VIII	329
February 6, 1957	42	115	180	160	400	195	230	165	52	2-4	F	IX	341
February 6, 1957	44	125	185	175			240	225	51		F	III	388
February 9, 1957	38	135	205	165	440	210	250	185	49		F	Unknown	390
February 9, 1957	40	130	205	170	405	220	255	195	50		F	Unknown	390
February 13, 1957	40	145	210	190	480	230	285	210	52	3-6	F	IV-V	378
February 14, 1956		155	230	200	461				64	4-3	F	VI	199.3
February 14, 1957	53	155	230	210	510	240	285	220	59	4-7	M	Unknown	382
February 19, 1957	54	148	200	195	505	225	300	230	59	2-10	M	IV	434
February 21, 1957	50	140	200	190	470	230	275	195	54	3-6	F	IX	398
February 21, 1957	50	145	220	185	500	220	300	180	53	3-5	F	IX	398
February 24, 1956		155	240	210	495				58	4-11	M	IV	194
February, 1956		165	250	215	500				65		M	Unknown	209
March 2, 1956		185	280	240	520				65	5-15	F	IV	202.3
March 2, 1957	45	155	210	185	480	220	290	210	58	3-15	F	II-III	401
March 3, 1956		195	315	260	610				69	7-2	F	V	212
March 4, 1956		195	310	260	610				69	6-11	M	VIII	208.4
March 4, 1957	75	219	295	275	610	260	390	280		8-7	M	II	415
March 5, 1957	75	200	290	270	600	290	360	270	69	7-10	M	V	414
March 9, 1956		205	330	285	627				72	7-14	M	VII	211.4
March 9, 1957	70	205	280	265		280			67	7-0	F	VI	417
March 12, 1957	78	215	290	285	640	275	370	305	72	9-9	M	III	429
March 14, 1957	64	200	265	250	615	255	340	290	70		M	IV	430

TABLE 5 (Continued)

ollection Date	Measurements in millimeters												
	Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.	Zygo. Arch	Weight (Pounds)	Sex	Age Class of Female	Accession No. R. A. R.
larch 14, 1957	65	195	265	250	600	255	330	270	71	6-14	M	IV	430
larch 19, 1957	68	200	270	255	590	265	340	351	68	8-4	F	I	428
larch 19, 1957	80	225	335	290	700	270	350	290		10-8	F	V-VI	None
larch, 1956		195	290	255	580				67		M	Unknown	208.7
larch, 1956		215	320	280	650				71	7-12	F	Unknown	None
pril 2, 1957	100	280	395	375	780	305	430	360	80	13-0	M	VI	448
pril 9, 1957	111	330	450	430	820	320	450	410	90	19-5	M	IV	450
pril 10, 1956		320	480	415	810				82	14-0	F	III	190.4
pril 10, 1957	104	290	370	360	780	310	410	350	78	15-0	F	IX	451
lay 2, 1956		335	500	435	790				81	14-0	F	VIII	1A
lay 2, 1956		310	455	395	740				81	14-0	M	VIII	2A
etuses from Fairbanks													
anuary 29, 1955	20	70	102	99	280	131	156	117	40	0-11	F	Unknown	285 JLB
ebruary 21, 1955	44	135	199	193	420	211	269	183	56	3-2	M	Unknown	291 JLB
larch	69	185	268	257	640	263	332	263	69	7-0	F	Unknown	290 JLB
larch	68	190	269		640	262	334			7-2	M	Unknown	289 JLB
larch 19, 1957	80	225	335	290	700	270	350	290		10-8	F	Unknown	None

[1] Measurements follow those described by Winters and Feuffel (1936), Winters, et al. (1942).
[2] Identification of sex by external anatomy impossible at this stage of development.

of reference, the tip of the nose and the tip of the tail, are more easily and accurately located than are the forehead-rump points. Another factor favoring the total length measurement is the tendency for the fetus to assume a "C" shape when preserved. This tendency does not affect the total length measurement but does affect the forehead-rump measurement.

Since no known-age fetuses are available for comparison, and because there is no possibility of obtaining any at present, it is necessary to make several assumptions in constructing the growth curve from the present data. The assumptions are based on the most complete available information and are: 1) the embryo-fetus transition in moose occurs between 40 and 43 days following conception, 2) the gestation period for moose is 240 to 246 days, and 3) that all fetuses grow at approximately the same rate.

Embryo-Fetus Transition. The embryo-fetus transition is an arbitrary but useful designation and has been described by Winters, et al. (1942) as that time at which organogenesis is complete and the remaining fetal growth is largely the development of existing organs.

The embryo-fetus transition for white-tailed deer, cattle, and sheep has been estimated by Armstrong (1950), Winters and Feuffel (1936), and Winters, et al. (1942) to occur at 37, 45, and 34 days, respectively. The period of the embryo occupies about 13 per cent of the total gestation period in these mammals. Application of this figure to the moose's gestation period of about 240 to 246 days indicates that the embryo-fetus transition should occur at about 42 to 43 days following conception.

Gestation Period. The assumption that moose have a gestation period of 240 to 246 days is based on estimates by a number of writers none of whom cite specific examples (Peterson, op. cit.).

Rate of Growth. The assumption that fetuses tend to grow at the same rate is based on the observations of Winters and Feuffel (op. cit.) and Armstrong (1950). These workers concluded that fetus size is primarily a function of growth-time, and that while individual variations and variations between single and multiple pregnancies do exist, these variations do not significantly affect the generalized growth curve.

Forty-six fetuses collected between January 6 and March 19, and which comprised what appeared to be the "best fit" or straight line portion of the data, were tested statistically, total length on time, following Snedecor's (1946) technique for determining linear regression. The regression line obtained from the fetus data was not sufficiently accurate within the .05 confidence limits to be used as a basis for estimating variation in conception dates, and for this reason a generalized-visually fitted, fetus-growth curve is used.

The curve which was fitted by inspection to the embryo-fetus data, illustrated in Figure 5, uses October 1 as its origin. This is an arbitrary date, but data presented in the previous sections on testis weights and parturition dates tend to substantiate an early October peak of conception, and the sizes and development of the embryos and fetuses collected in October and November indicate conceptions in late September and early October. If the curve in Figure 5 accurately reflects the growth of moose fetuses, then important information pertaining to the duration and peak of conception can be obtained from it. If the growth curve is used as a constant to which the other fetuses are compared, then all fetuses lying to the left of the curve were conceived prior to the average date, and all fetuses to the right of the curve were conceived after the average date. The variation in time of conception, measured in days, can be obtained by dropping two straight lines to the abscissa of the curve. One line is dropped from the point representing the total length of the fetus. The other is dropped from the point on the average curve equal in total length to that of the fetus in question. The distance between the two lines represents the difference in time of conception.

The peak and duration of the period of conception curve (Figure 6) was constructed by grouping the fetus-variation as determined from Figure 5 into three-day periods and converting each three-day period to a per cent of the total variation. Thus, for example, if 10 fetuses were conceived in the three-day period just prior to the arbitrary October 1 starting date and a total of 63 fetuses are present in the sample, then the three-day period just prior to October 1 accounts for roughly 16 per cent

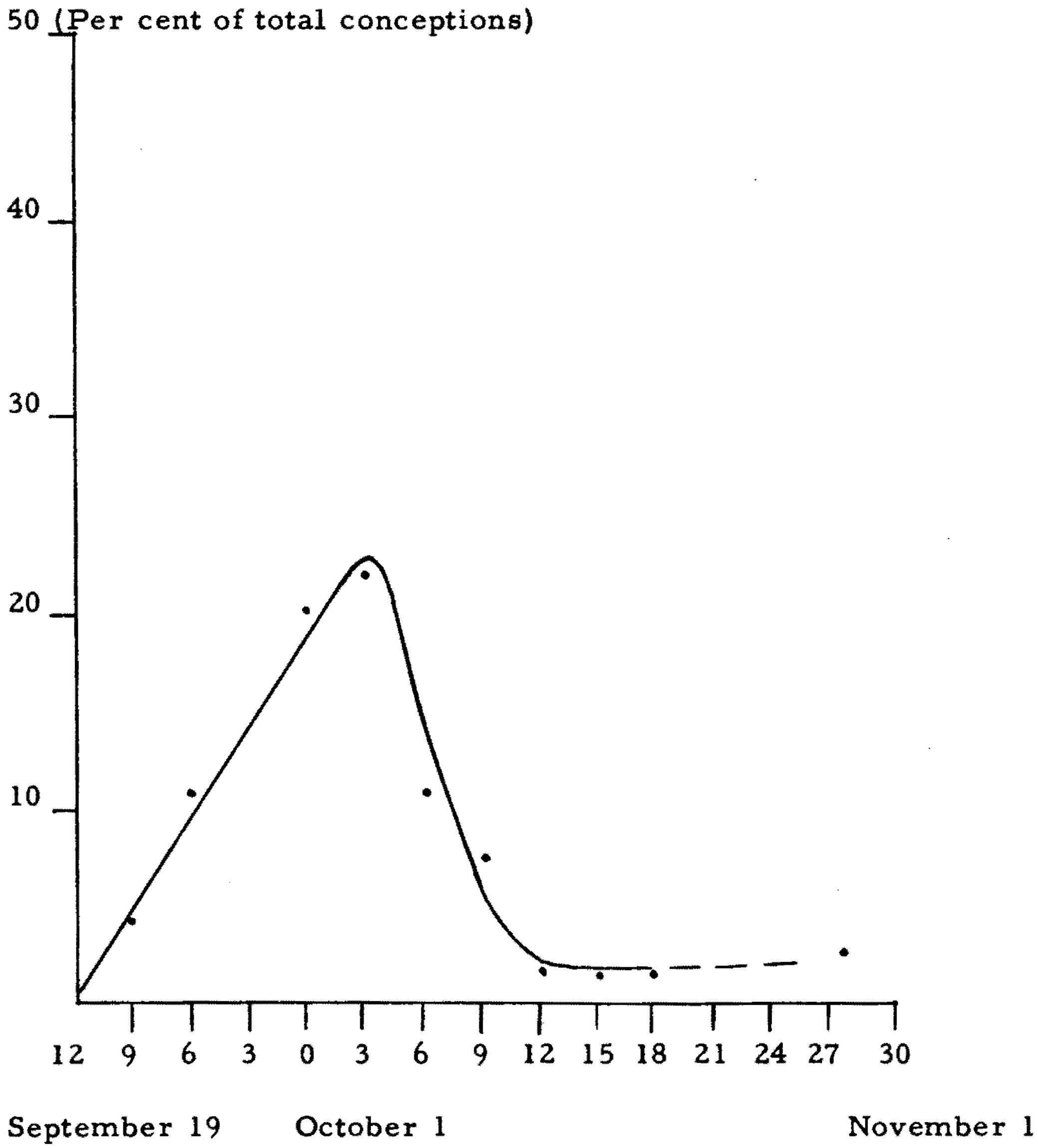

Figure 6. The peak and duration of conception in moose as measured by the variation in total length of 63 fetuses which were compared to the "average growth curve" in Figure 5.

of the total conceptions. These data reveal that 60 per cent of the fetuses in this sample were conceived in a 10-day period; that 80 per cent were conceived within a 15-day period; and that all individuals in this sample were conceived within a 40- to 45-day period.

If the curve and the October 1 starting point are essentially correct, then the earliest conceptions occur in mid-September and the latest in late October. This period indicates one or possibly two additional oestrous cycles in moose not conceiving during their first oestrous, or an extended period of ovulation possibly due to age-differential ovulation.

While deer are known to experience several oestrous cycles annually if they do not conceive during the first cycle (Cheatum 1946), data illustrating additional oestrous periods in moose are meager. Examination of the ovaries from a Class IX female killed on November 14, 1956, at Mile Post 184.4 on the Alaska Railroad, revealed what appeared to be a degenerating corpus luteum of oestrous and a developing follicle which burst when handled. Also, the uniformity of the conception dates of three fetuses (Accession Numbers 979, 1A, and 2A) which fall far to the right of the average growth curve suggest a possible second oestrous in Alaskan moose. The data, based on fetus size distribution, from moose in the Wells Gray Park in British Columbia clearly indicate at least four oestrous cycles (Ritcey and Edwards, 1958).

Data suggesting an age-differential ovulation are similarly meager. Fetus 979 (collected January 9, 1958), Table 5, from a Class I female was probably conceived late in October. Female 806, Table 6, collected November 10, 1957, also a Class I individual, had ovulated, but the corpus luteum had not completely lutenized, suggesting a recent ovulation. The sizes of the fetuses from Class II and III females appear to be randomly distributed (Table 5). Yearling females possibly ovulate later than older animals, but the few yearlings that do ovulate do not markedly influence the age-size distribution of the fetuses. The range in fetus sizes and conception dates is probably caused by cow moose experiencing additional oestrous cycles if they do not conceive during the first cycle, and by normal variation in oestrous dates.

Other Observations on Rut Activities. Additional observations on the progress of rut were obtained from field examination of hunter-killed animals and from aerial sex and age composition counts.

On September 17, 1957, the writer killed a yearling bull which had a large cow accompanying it. The pair was observed for 30 to 45 minutes before the bull was shot. During this period the male evidenced much interest in the cow but did not attempt to mount her. Examination of his stomach contents revealed he had ingested some urine--typical of rutting bulls. On September 20, 1957, R. O. Skoog, Wildlife Management Biologist, United States Fish and Wildlife Service, killed a three to four year old bull near the Susitna River bridge along the Denali Highway; he reports that this bull also had ingested a considerable amount of urine.

TABLE 6. NOTES ON SIZE AND DEVELOPMENT OF OVARIES COLLECTED FROM MOOSE IN SOUTH CENTRAL ALASKA

Date of Collection	Age Class of Female	Weight of Ovaries (milligrams) I	II	Corpus Luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of Largest Follicle (millimeters)	Accession No. R. A. R.
December 18, 1956	Calf	650		0	0	0	1	323
December 18, 1956	Calf		Lost					323
December 23, 1956	Calf	950		0	0	0	1	301
December 23, 1956	Calf		900	0	0	0	1	301
January 26, 1957	Calf	1000		0	0	0	2	327
January 26, 1957	Calf		1000	0	0	0	2	327
February 3, 1957	Calf	1000		0	0	0	1	223.5
February 3, 1957	Calf		950	0	0	0	1	223.5
February 13, 1957	Calf	1400		0	0	0	1	379
February 13, 1957	Calf		1400	0	0	0	1	379
February 14, 1957	Calf	350		0	0	0	1	389
February 14, 1957	Calf		Lost					389
August 31, 1957	I	1800		0	0	0	7	543
August 31, 1957	I		Lost					543
September 2, 1957	I	1250		0	0	0	1	536
September 2, 1957	I		600	0	0	0	?	536
Fall, 1957	I	1100		0	0	0	?	B-25
Fall, 1957	I		Lost					B-25

TABLE 6 (Continued)

Date of Collection	Age Class of Female	Weight of Ovaries (milligrams) I	Weight of Ovaries (milligrams) II	Corpus Luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of Largest Follicle (millimeters)	Accession No. R. A. R.
November 10, 1957	I	3350		1[1]	?	0	2	806
November 10, 1957	I		1300	0	0	0	2	806
November 24, 1957	I	1050		0	0	0	2	840
November 24, 1957	I		Lost					840
December 18, 1956	I	2700		0	0	0	1	313
December 18, 1956	I		2700	0	0	0	1	313
January 17, 1957	I	1250		0	0	0	6	342
January 17, 1957	I		1200	0	0	0	2	342
January 24, 1958	I	--		0	0	0	2	990
January 24, 1958	I		--	0	0	0	2	990
March 19, 1957	I	3550		1	1	0	10	428
March 19, 1957	I		1875	0	0	0	4	428
September 2, 1957	II	2350		0	0	0	9	513
September 2, 1957	II		1850	0	0	1	7	513
October 31, 1957	II	--[2]		1	1	0	6	677
October 31, 1957	II		Lost					677
March 4, 1957	II	3650		1	1	1	8	415
March 4, 1957	II		1800	0	0	0	1	415

TABLE 6 (Continued)

Date of Collection	Age Class of Female	Weight of Ovaries (milligrams) I	II	Corpus Luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of Largest Follicle (millimeters)	Accessi No. R. A. R.
August 24, 1957	II	2100		0	0	0	9	559
August 24, 1957	II		2650	0	0	2	11	559
January 9, 1958	II	1150		0	0	1	1	979
January 9, 1958	II		2600	1	1	0	4	979
March 2, 1957	II	3550		1	1	2	8	401
March 2, 1957	II		1615	0	0	1	4	401
August 22, 1957	III	2650		0	0	0	12	528
August 22, 1957	III		2000	0	0	2	3	528
November 2, 1956	III	5350		1	1	0	20	302
November 2, 1956	III		4000	0	0	0	20	302
February 13, 1957	IV	4900		1	1	4	5	378
February 13, 1957	IV		2700	0	0	4	9	378
February 16, 1957	IV	1950		0	2	4 or 5	4	430
February 16, 1957	IV		Lost					430
March 2, 1956	IV	3450		1	1	0	?	177
March 2, 1956	IV		Lost					177
April 9, 1957	IV	4300		1	1	1	7	450
April 9, 1957	IV		1750	0	0	1	1	450

TABLE 6 (Continued)

Date of Collection	Age Class of Female	Weight of Ovaries (milligrams) I	II	Corpus Luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of Largest Follicle (millimeters)	Accessi No. R. A. R.
October 2, 1957	V	4050		0	0	3	4	595
October 2, 1957	V		5150	0	0	0	10	595
January 9, 1958	V	3250		0	0	0	14	980[3]
January 9, 1958	V		6550	2	1	0	3	980
March 3, 1956	V	5700		1	1	1 or 2	6	191
March 3, 1956	V		3150	0	1	1	1	191
March 5, 1957	V	4700		1	1	3	7	414
March 5, 1957	V		2250	0	1	3	1	414
August 25, 1957	VI	4400		0	0	3	9	521
August 25, 1957	VI		5000	0	0	7	5	521
September 2, 1957	VI	2800		0	0	4	3	531
September 2, 1957	VI		3050	0	0	2	14	531
September 15, 1957	VI	3300		0	0	3 or 4	7	586
September 15, 1957	VI		3000	0	0	3	3	586
March 4, 1956	VI	4900		1	1	5	6	222
March 4, 1956	VI		2600	0	0	4	2	222
March 9, 1957	VI	4500		1	1	4	4	417
March 9, 1957	VI		3750	0	0	5	3	417

TABLE 6 (Continued)

Date of Collection	Age Class of Female	Weight of Ovaries (milligrams) I	II	Corpus Luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of Largest Follicle (millimeters)	Accession No. R. A. R.
April 2, 1957	VI	3400		1	1	4 or 5	?	448
April 2, 1957	VI		1650	0	0	3	?	448
June 9, 1957	VII	2300		0	Lactating	3	4	500
June 9, 1957	VII		2750	1	Lactating	3	4	500
November 15, 1956	VIII	2650		1[4]	0	6 or 7	?	184.4
November 15, 1956	VIII		1500	0	0	5	6	184.4
November 3, 1957	IX	5450		1	1	4 or 5	3	676
November 3, 1957	IX		4250	0	0	3	7	676
January 6 to 9, 1958	IX	3450		1	1	6	2	976
January 6 to 9, 1958	IX		3750	1	1	7	7	976
February 6, 1957	IX	5500		1	1	4	5	341
February 6, 1957	IX		3500	0	0	2	10	341
February 21, 1957	IX	5450		2	2	1[5]	?	398
February 21, 1957	IX		2400	0	0	4	10	398
April 10, 1957	IX	4000		1	1	4	7	451
April 10, 1957	IX		2150	0	0	6	1	451

[1] Not definitely pregnant; had ovulated.
[2] Partially destroyed.
[3] Had decomposed somewhat--identification of corpora albicantia not possible.
[4] May be corpus luteum of oestrous; not of pregnancy.
[5] Did not complete dissection of this ovary.

Aerial sex and age composition counts of the moose populations inhabiting the Clear Creek and Maclaren River drainages on October 8 and 9 and on the Susitna River area on October 10, 1957, tallied 456 animals. Most (76 per cent) of these animals were found in "harem-like" groups of 3 to 21 animals. The moose were generally distributed along the creek bottoms in dense willows 6 to 12 feet high. Moose were under almost continuous observation for eight hours, but no bulls evidencing interest in cows were seen. In fact some of the large bulls were leaving the breeding groups and others were beginning to eat again, suggesting that the period of active rut was past. Evidence of recent rutting activity was abundant on willow-and-alder-covered benches some 200 to 400 feet above where the majority of the moose were tallied. Nearly 100 rut pits ("brunstgropen") were counted. These excavations are reportedly made by bulls alternately pawing, urinating and rolling in them during extreme excitement of the rut (Peterson, 1955). Mating reportedly takes place in the immediate vicinity of these pits (Lonnberg, 1923). This area was covered by 3 to 4 inches of snow some three to four days previous to the counts. Fresh trails led from the breeding area to where the moose had regrouped in the valley areas, a distance of approximately one to two miles. The presence of rut pits and the subsequent movement of the moose to another area also suggest that the peak of the breeding portion of the rut had passed.

<u>Summary of Rut.</u> The breeding activities of the moose inhabiting

the Railbelt and Matanuska Valley commence in late August, when the bulls first start polishing or rubbing their antlers, and continue through September, October, and early November.

Spermatogenesis, as evidenced by presence of spermatozoa in the epididymis has begun at least by August 20 and continues at least until December (Table 1). Examination of ten sets of ovaries in August and early September revealed developing follicles, but none of the females had ovulated (see Fertility). One set of ovaries collected on October 2 contained several large follicles. The largest follicle ruptured when handled, possibly indicating that this cow was about to ovulate.

The combined data of testes weights, parturition observations, embryo and fetus measurements, ovarian analysis, and field observations, indicate that the peak of conception occurs sometime in late September or early October, probably about October 1 to 3. About 80 per cent of the fetuses in a sample of 63 were conceived within a 15 day period and all of them were conceived within a 40 to 45 day period. This suggests that most females are bred during their first oestrous, but that subsequent oestrous periods may occur if the female does not conceive during the first. It is also possible that the length of the period of conception is caused by age-differential ovulation, the yearlings breeding somewhat later.

Fertility

Fertility, as used here, refers to the potential reproductive ability of female moose. Fertility data were collected from 106 female moose during the period from January, 1956, through June, 1958. These moose were examined as a result of highway, railroad, and illegal kills. In many instances complete information was available, and jaws, ovaries, and fetuses, if present, were collected.

Analysis of Ovaries. During this study 31 pairs and five individual ovaries were collected from 36 moose Age Class I or older (Table 6).

Connective scar tissue, the corpora albicantia, formed by the degenerating corpora lutea of pregnancy, has been used by Cheatum (1949) to estimate the previous year's reproductive performance of certain white-tailed deer populations. In identifying the number of corpora albicantia present, Cheatum assumed that all pigmented scars represented the past gestation period's corpora lutea of pregnancy, and that the pigmented scars resulting from other ovarian functions could be eliminated on the basis of their smaller size. Golley (1957), working with black-tailed deer, presented data which indicate that some pigmented scars from ovarian functions other than pregnancy are present and that the fate of the corpora albicantia of the corpora lutea of pregnancy is not consistent. In black-tailed deer, this resulted in 18 per cent more corpora albicantia being tallied in ovaries collected during the anestrous period than there are corpora lutea of pregnancy present in ovaries collected during the gestation period. Thus, in some ungulates, corpora albicantia counts yield a general indication of the success of the immediate past reproductive period, but current researchers are not in agreement on the accuracy of the technique.

Seventy-nine moose ovaries from 36 females (Table 6) were sectioned, sagitally, with a razor blade and examined for the presence of corpora lutea of pregnancy and for corpora albicantia of corpora lutea of pregnancy. The sections were of varying thickness, but were thin enough to allow the passage of light and thereby permitted detection of pigmented bodies and large follicles. In moose the corpus luteum of pregnancy is large, frequently 10 to 18 millimeters at its greatest diameter, and is easy to find. The corpora albicantia of corpora lutea of pregnancy are smaller, dark, pigmented scars, varying in color from light-brown to almost black. The usual size is from 4 to 8 millimeters at the greatest diameter. Occasionally smaller pigmented bodies are observed, but these are not counted (Cheatum, op. cit., and Golley, op. cit.).

Examination of the moose ovaries collected during this study revealed a number of interesting data; of particular interest are the following: 1) follicle development and ovulation, 2) types of ovulation, 3) corpora albicantia as indicators of past pregnancies, and 4) ovaries as indicators of fertility.

Follicle Development and Ovulation. Ten sets of ovaries were collected during the period from August to mid-October (Table 6). All ovaries from animals older than Class I had one or more developing follicles, which ranged from 3 to 14 millimeters in diameter. One Class I animal, collected on August 31, had a developing follicle 7 millimeters in diameter. In specimens Accession Numbers 531 and 586, collected in early and mid-September, the follicle walls were very thin. An ovary of female Accession Number 595 collected on October 2, 1957, contained a follicle 10 millimeters in diameter which ruptured when handled. Although all the ovaries collected during late August, September, and early October had large developing follicles present, the data are too limited to indicate trends on ovulation dates. The data do indicate that all the animals in this sample older than Class I were potentially fertile.

Types of Ovulation. The number of corpora lutea of pregnancy present in moose ovaries usually corresponds to the number of fetuses present. Thus if twin fetuses were present two corpora lutea were usually present; however, several interesting variations were observed. One pair of ovaries had a single corpus luteum and twins were present; another had two corpora lutea and a single fetus, and no evidence of resorption of a second fetus was observed in this animal. In animals carrying twin fetuses the corpora lutea were located one in each ovary, two in one ovary, and as previously mentioned, one instance of a single corpus luteum.

Corpora Albicantia as Indicators of Past Pregnancies. The number of corpora albicantia or pigmented scars in moose ovaries has a direct relationship to the age of the individual (Table 2). This suggests that, in moose, the corpora albicantia of corpora lutea of pregnancy persist for a considerable time and possibly throughout the animal's life. Thus, estimating the past breeding season's success from corpora albicantia counts is not considered feasible. Likewise estimates of the reproductive history of individual animals from pigmented scar counts is not considered feasible other than in a general way, because of the possible extra scars which are produced through multiple ovulation and extra oestrous cycles. In the present sample, however, errors due to extra corpora albicantia developing from supernumeray corpora lutea of pregnancy would be minimal, because the number of corpora lutea of pregnancy and fetuses are nearly equal.

Ovaries as Indicators of Fertility. The data obtained from examination of 79 ovaries from 36 moose Age Class II or older reveals that a corpus luteum of pregnancy or a developing follicle was present in each animal. If one assumes that the developing follicles ruptured, then 100 per cent of the animals in this sample were fertile.

Incidence of Pregnancy. The term "incidence of pregnancy" as used here refers to the per cent of females pregnant at the time of examination. The sample includes animals collected from late October through May, the period when sexually mature female moose are normally pregnant. The definition does not allow for resorped embryos, abortion or other prenatal losses; however, only one instance of possible prenatal loss was observed, and this case could not be verified.

The "barren cow moose" is a concept apparently accepted by many;

theoretically under certain adverse conditions, such as, disease, malnutrition, or an unbalanced sex ratio, a large portion of the cows could lose their fetuses or remain barren. This, however, does not appear to be a problem in the Matanuska Valley and Railbelt areas, where available winter browse appears insufficient, and the bull:cow ratios are as low as seven bulls per 100 cows, as 87 of 93 (94 per cent) cows older than yearlings were pregnant (Table 7).

In an effort to measure the relative calf production of young and old moose and to minimize the aging technique problems, the eight recognizable age classes of breeding-age females (see Sex and Age Composition) were lumped into four age categories. (Yearlings--Class I--are discussed in Age at Sexual Maturity section).

1) The age category of Class II and III individuals, unfortunately the most difficult age classes to separate, includes the period at which female moose reach sexual maturity (see Age at Sexual Maturity).

2) The category of Age Classes IV and V, which probably includes moose of 3 1/2 to 6 1/2 years, coincides with early physical prime, and in this sample is represented by 30 individuals. No barren cows were found in this group.

3) The age category composed of Classes VI and VII probably represents moose of 6 1/2 to 10 1/2 years; only 1 of 14 animals examined was barren.

4) The oldest group, Age Classes VIII and IX, probably represents moose 10 1/2 to 20 years old; only 2 of 17 cows examined were barren.

TABLE 7. COMPARATIVE REPRODUCTIVE DATA FROM 98 COW MOOSE, AGE CLASS I TO IX, COLLECTED FROM JANUARY, 1956, TO JUNE, 1958, IN SOUTH CENTRAL ALASKA

Age Class	No. Cows	Per cent This Sample	Sets of Twins	Singletons	Barren Cows	Total No. Fetuses	Per cent Total Fetuses This Sample	Fetuses: 100 Cows	No. Pregnant Cows	Twins:100 Pregnancies
I	5	5	0	1	4	1	.9	20	1	0
II-III	17	17.5	1	14	2	16	14.3	94	15	7
IV-V	30	31	9	21	0	39	34.9	130	30	30
VI-VII	14	14.5	2	11	1	15	13.3	107	13	15
VIII-IX	17	17.5	7	8	2	22	19.7	129	15	47
Unknown	15	15.5	5	9	1	19	16.9	127	14	36
Totals	98	100	24	64	10	112	100	115	88	27
					Excluding Class I			123		
					Fetuses:100 Pregnancies			129		
					Pregnancies:100 Cows			90		
					Excluding Class I Individuals			94		

Although the present data are limited in number, there is no indication that female moose in southern Alaska live past their reproductive age even though hunting of cows is prohibited.

Only 1 of 15 unknown-age females above Age Class I was barren. Thus, as mentioned earlier, 94 per cent of all female moose examined, above Age Class I, were pregnant.

Another important factor in evaluating the relative reproductive importance of each age category is the number of calves produced by the animals comprising a particular age category. The production of calves is expressed as calves per 100 cows, and the barren cows are included in the computations (Figure 7 and Table 7). These data reveal that the younger age groups, Age Classes II and III, produce fewer calves, and that the oldest age group, VIII and IX, continues to produce calves.

The rate of twinning is still another factor contributing to the importance of a particular breeding age group. Figure 7 indicates that the youngest breeding age group, Age Classes II and III, has the lowest rate of twinning as well as the lowest fetus:cow ratio (excepting Class I individuals which are not considered a breeding group). The oldest age group has the highest rate of twinning: 47 sets per 100 pregnancies.

The age category composed of Age Classes VI and VII, presumed to represent moose in late prime of life, is difficult to interpret as both the calf:cow and twinning rate are lower than expected. This is probably the result of a small non-representative sample.

These data indicate that potential reproduction in the Railbelt and

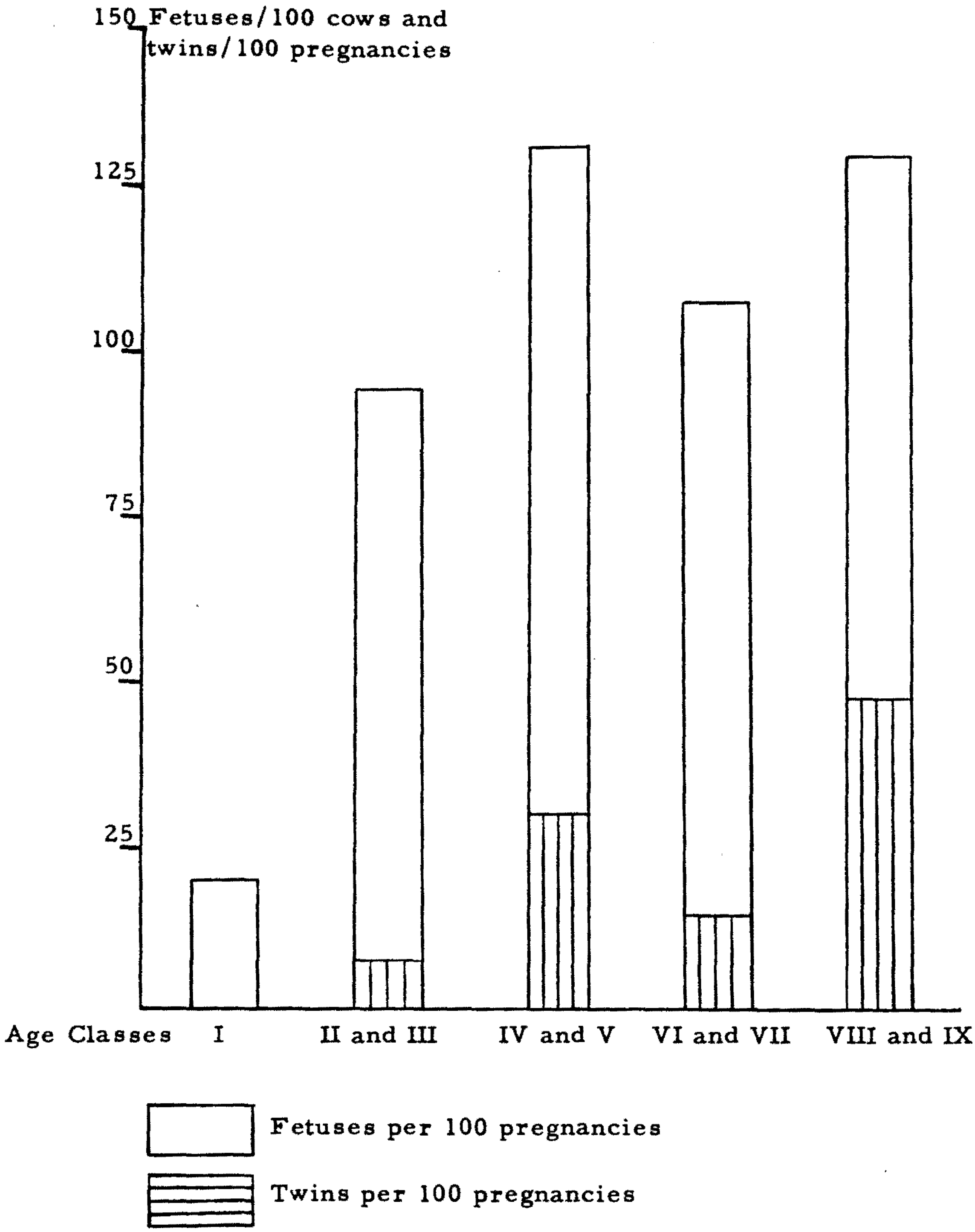

Figure 7. Comparative potential reproduction of five age categories of cow moose.

Matanuska Valley moose populations is very good; that great hunting pressure, even reducing the bull:cow ratio to 10 per 100 or less has not lowered the incidence of pregnancy of the moose populations; and that hunting only bulls is not an effective means of controlling moose numbers.

SEX AND AGE COMPOSITION

Sex and age data were obtained from 476 moose, from Age Class Fetus to Age Class IX (Table 8). The sex and age information for Age Classes Fetus and Calf represent all specimens collected, and include animals collected as a result of railroad and highway accidents and illegal kills. The specimens represented in Age Classes I to IX were killed by trains between Mile Posts 150 and 250 on the Alaska Railroad during the winters of 1955-56 and 1956-57.

Sex Composition

Sex ratios of many mammals, including cervids, approximate a 100:100 ratio at birth with, perhaps, a slight numerical superiority of males indicated for some species (Robinette, et al., 1957). Under certain favorable conditions sex ratios at conception of many North American ungulates indicate a definite numerical superiority of males at conception, but sex-selective mortality factors tend to reduce this superiority even during the prenatal period. Robinette, et al. (op. cit.), working with mule deer, presented a review of the literature on sex-differential mortality as well as considerable quantitative data on mule deer sex ratios, both pre and postnatal. The literature and data presented show that there are exceptions to the general belief that males outnumber females at birth; this is especially apparent when dealing with local populations. Some factors which may influence the sex ratio at birth are as follows: age structure of the population, average age and past

TABLE 8. SEX AND AGE COMPOSITION OF THREE LOCAL MOOSE POPULATIONS (AS OBTAINED FROM RAILROAD-KILLS, THE WINTERS OF 1955-56 AND 1956-57).

Age Classes and Area by Mile Posts	Males	Females	Total Sample	Males:100 Females	Per cent of Males in Each Local Population	Per cent of Females in Each Local Population	Per cent of Total Sample
Fetuses	37	36	73	103			
Calves	64	65	129	98			
Class I							
150-175	2	1	3	200	40	5	
176-200	2	2	4	100	10	3	
201-250	9	6	15	150	15	8	
Combined	13	9	22	144	15	6	9
Class II and III							
150-175	2	3	5	66	40	12	
176-200	5	7	12	71	23	12	
201-250	11	18	29	61	18	25	
Combined	18	28	46	64	21	18	19
Class IV and V							
150-175	1	6	7	16	20	25	
176-200	10	20	30	50	45	34	
201-250	23	20	43	115	38	28	
Combined	34	46	80	74	39	30	33

TABLE 8 (Continued)

Age Classes and Area by Mile Posts	Males	Females	Total Sample	Males:100 Females	Per cent of Males in Each Local Population	Per cent of Females in Each Local Population	Per cent of Total Sample
Class VI and VII							
150-175	0	8	8	0	0	33	
176-200	4	18	22	22	18	31	
201-250	12	19	31	63	20	27	
Combined	16	45	61	35	18	29	25
Class VIII and IX							
150-175	0	6	6	0	0	25	
176-200	1	11	12	9	5	19	
201-250	5	8	13	62	8	11	
Combined	6	25	31	24	7	16	13
Combined Totals							
150-175	5	24	29	21			
176-200	22	58	80	38			
201-250	60	71	131	84			
Totals	87	153	240	57			

reproductive history of the females, the level of nutrition before and after conception, and the severity of the winter during the gestation period. Although these factors can affect the male:female ratio at birth, there seems to be no way to predict which sex will be favored; generally, however, the male suffers the greatest mortality.

Robinette, et al. (op. cit.) indicates that postnatal sex-selective mortality factors in mule deer apparently affect males at a greater rate during the early months, but that females die at a greater rate during the first winter; this differential mortality is reversed during the second winter when the mortality rate for males is roughly twice that of females.

The present data on the sex ratio of moose fetuses are limited, but information from 63 fetuses indicates a sex ratio of 103 males per 100 females. The sex ratio of 14 sets of twin fetuses was 16 males to 12 females or 133 males per 100 females. The sex composition of the 14 sets of twins was as follows: two males, 5 sets; one male and one female, 6 sets; and two females, 3 sets.

The sex ratio of 129 moose calves, varying in age from 1 to 10 months, was 64 males to 65 females or 98 males per 100 females. This is essentially a 100:100 ratio, as was found in the prenatal specimens.

The sex ratio of animals older than calves is distorted by hunting. The influence of hunting on the sex ratios of the moose population can be illustrated by dividing the study area into three local areas which are subjected to varying degrees of hunting pressure (Figure 2). The areas are as follows: Area I, the Matanuska Valley, Mile Posts 150 to 175 along the Alaska Railroad; Area II, the Willow area, Mile Posts 176 to 200 along the Alaska Railroad; and Area III, the Kashwitna-Talkeetna area, Mile Posts 201 to 250 along the Alaska Railroad. These areas represent moose populations subjected to intense, less intense but heavy, and practically no hunting pressure, respectively.

The moose represented in Table 9, older than Age Class Calf, were killed by trains during the winters of 1955-56 and 1956-57. The eight age classes above Age Class I have been combined into four age categories in an attempt to compensate for the aging technique difficulties (see Age Composition). Although the samples from each local area are small, the effect of hunting on the male segment of the moose population in Areas I and II is apparent. The bull:cow ratios in Areas I and II are 21 and 38 bulls per 100 cows, respectively. The sex ratio in Area III, which is subjected to little hunting pressure, is 84 bulls per 100 cows, and in this sample is not statistically different from a 100:100 ratio. Aerial counts made on Area III in 1957 and 1958, however, do indicate a significant difference at the .05 level. This suggests that the small sample of railroad-killed moose, while not statistically significant, probably does represent a biological fact. The sex ratio of the three oldest age classes (VII, VIII, and IX), 46 bulls per 100 cows, is significantly different from a 100:100 ratio, and suggests that sex differential mortality factors possibly affect males at a greater rate than females.

The assumption that sex ratios obtained from examination of train-killed moose are representative of the existing moose populations

TABLE 9. SEX AND AGE COMPOSITION OF RAILBELT AND MATANUSKA VALLEY MOOSE POPULATIONS BY AGE CLASS (AS OBTAINED FROM RAILROAD KILLED MOOSE DURING THE WINTERS OF 1955-56 AND 1956-57)

Area and	1955-56		1956-57		Combined		Males:100
Age Class	Male	Female	Male	Female	Male	Female	Females
Area I--Mile Posts 150-175							
I	1	1	1	0	2	1	
II	0	0	0	1	0	1	
III	1	2	1	0	2	2	
IV	0	2	0	2	0	4	
V	1	1	0	1	1	2	
VI	0	4	0	1	0	5	
VII	0	2	0	1	0	3	
VIII	0	1	0	0	0	1	
IX	0	5	0	0	0	5	
Totals	3	18	2	7	5	24	21
Area II--Mile Posts 176-200							
I	1	2	1	0	2	2	
II	0	2	0	0	0	2	
III	3	3	2	2	5	5	
IV	3	8	3	3	6	11	
V	3	6	1	3	4	9	
VI	2	6	1	0	3	6	
VII	0	8	1	4	1	12	
VIII	1	4	0	1	1	5	
IX	0	6	0	0	0	6	
Totals	13	45	9	13	22	58	38
Area III--Mile Posts 201-250							
I	8	4	1	2	9	6	
II	1	3	3	3	4	6	
III	4	4	3	8	7	12	
IV	5	4	7	4	12	8	
V	9	9	2	3	11	12	
VI	6	10	5	1	11	11	
VII	1	8	0	0	1	8	
VIII	3	5	0	0	3	5	
IX	2	2	0	1	2	3	
Totals	39	49	21	22	60	71	84

is supported by the sex ratio data obtained from aerial sex and age counts made on approximately the same local moose populations. The sex ratios obtained by the two sampling techniques are similar. The overall bull:cow ratio as indicated by the railroad kill is 57 bulls per 100 cows. The same ratio obtained from aerial composition counts is 44 bulls per 100 cows. The two samples are not directly comparable, however, because most of the railroad sample came from Area III which is not hunted, whereas, over half of the aerial sample represents a heavily hunted area. Nevertheless, trains appear to sample proportionately the moose populations inhabiting the areas adjacent to the right-of-way.

Sex ratios of moose calves, as indicated by the present small samples, appear to be essentially 100:100. The sex ratios beyond Age Class Calf are distorted by hunting, but in Area III, where hunting is limited by accessibility, natural mortality possibly affects males at a greater rate than females.

Age Composition

Data on the age of 240 moose, Age Class I to IX, were obtained from animals killed by trains between Mile Posts 150 and 250 on the Alaska Railroad. These data are presented in Tables 8 and 9.

Age determinations of moose, based on comparative wear of the mandibular teeth, have been described by Skuncke (1949), Lensink (1955), and Peterson (1955). All three of the aging techniques are based on diagnostic characteristics of tooth wear, and jaws evidencing similar wear were placed in the same age class. Apparently, only Skuncke had some known-age jaws for comparative purposes. All three of these writers describe nine general age classifications, excluding calves. In all probability only the first three age classes correspond to the chronological age of the animal. In analyzing the material presented here the writer used a key constructed by Lensink (op. cit.). Subsequent cross-checking by Lensink revealed that complete agreement with the writer's age determinations was not obtained even on Age Classes II and III when using the key alone. Since comparative wear is difficult to evaluate quantitatively, classification of jaws based on experience and comparison with a set of known-age or approximate-age jaws seems a more desirable technique. Quimby, et al. (1957), working with elk and having known-age jaws for comparison, concluded that no single characteristic or combination of characteristics of wear satisfactorily separated animals with "full mouths", and while not absolute, the best technique was visual comparison with known-age jaws. In his conclusion he further states, ". . . familiarity gained by handling large numbers of jaws seems to provide the best criteria for establishing age classes."

Experience, plus a set of approximate-age jaws, is the technique finally employed to classify the jaws discussed in this section of the report. Age Class II and beyond undoubtedly include more than one year class. Thus, the seven age classes beyond Class II represent moose from 3 to 20 years of age. In all probability the older age classes represent three to five year groups.

Hunting changes the age composition of the bull population segment and for this reason bulls and cows are considered separately in Tables 8 and 9. Very few bulls survive to Age Classes VIII and IX in the three local areas studied. The reason for the poor survival of bulls in Area I and II is directly attributable to removal by hunting. The mortality factors affecting bull survival in Area III are not known.

The status of the population as reflected by age composition is best assessed from age determinations of the female segment, because, as has been previously discussed, males are removed by hunting. Again, the lack of accurate age criteria, especially for year classes, compounds the problems involved in analyzing the importance of the population age structure. The basic problem involved is determining the exact number of year classes represented by a particular age class. However, until known-age specimens are available the desired breakdown will not be possible and analysis of population age structure based on the nine recognizable age categories or combinations thereof must be considered as only a general indication of population age structure.

Several interesting population trends are revealed through analysis of the age structure of the 1955-56 railroad-killed moose. The data obtained from the 1955-56 kills are used, instead of a cumulative total kill for a number of years, because of the desirability of analyzing the fate of several important year classes. The 112 cow moose, Age Class I to IX, killed by trains during the winter of 1955-56, are listed in Table 10 by age class and per cent of total.

TABLE 10. AGE OF 112 COW MOOSE KILLED BY TRAINS THE WINTER OF 1955-56 BETWEEN MILE POSTS 150 AND 250 ON THE ALASKA RAILROAD

Age Class	No. of Moose	Per cent of Total
I	7	6
II	5	5
III	9	8
IV	14	13
V	16	14
VI	20	18
VII	18	15
VIII	10	9
IX	13	12
Total	112	100

Analysis of these data reveal that kills from Age Classes I and II comprise only six and five per cent, respectively, of the total females killed. Cross-checking with the 1954 and 1953 fall aerial sex and age composition counts, when the 1955-56 Class I and most of the Class II animals were calves, revealed calf:cow ratios of 40 and 44 calves per 100 cows, respectively. If no mortality or very little mortality had occurred to the 1954 and 1953 calves from the time of the aerial counts to the time of the 1955-56 railroad-killed sample, and assuming a 100:100 sex ratio, then the 1955-56 winter sample of the female population should contain approximately 15 per cent Class I and II individuals, respectively. Thus, if the sample of railroad-killed animals is representative of the existing female population, great mortality has occurred to these age classes.

Quantitative evidence pertaining to the mortality factors possibly affecting the 1953 and 1954 calves are not available. Limited field observations made by Fish and Wildlife Service personnel, however, suggest that the unusually severe winters of 1953-54 and 1954-55 may have been the principal mortality factor.

The age structure of the Railbelt moose populations, as indicated by train-killed moose for the years of 1955-56 and 1956-57 has a preponderance of middle-aged and old females. However, the age structure of the cow segment of the three local populations as revealed by the sample of railroad-killed females appears quite different. The differences, however, are not significant at the .05 level. In Areas I and II, 58 and

50 per cent, respectively, of the cows are of Age Class VI, or older, whereas in Area III only 38 per cent of the cows are represented in the older age classes. The percentages of females in the oldest age category, Age Classes VIII and IX, from the three areas are as follows: Area I, 25 per cent; Area II, 19 per cent; and Area III, 11 per cent. These data suggest that the age structure of the population in Area III is possibly younger than that of Area I. The most obvious differences between the two areas which might affect population age structure are climatological. Area I is subjected to frequent strong winds throughout the winter. The winds tend to reduce the snow cover thereby allowing moose easier travel to browse areas and also making more browse available to the moose. The winter average temperatures in Area I are considerably warmer than those of Area III (Climatological Data, Alaska, 1955). Area III lies within a deep snow belt, frequently 40 or more inches of snow cover the ground and consequently the low shrubs, thereby reducing the amount of available winter browse.

Theoretically the more favorable climate of Area I should allow for a greater survival of calves and for better survival of the oldest age class individuals. The harsh winters of Area III could cause increased mortality of calves and old animals. The data obtained from the railroad-killed moose indicate that the two populations are possibly responding to the effects of climate as illustrated in the preceding discussion. Area I has a very dense population of moose, with a considerable number of old females. Area III has considerably fewer moose per square mile but has an overall younger population.

Other factors may be affecting the age structure of these populations. The numbers of moose in Area III may be increasing, although there is no data to indicate a substantial increase in moose numbers in this area. Area I populations possibly are decreasing, hence an unbalanced old population; however, the annual calf:cow ratios indicate that production is excellent and the 1957 hunting season revealed that survival of bull calves to 16 months was very good.

SURVIVAL

In most mammals the greatest mortality occurs in the youngest age group--the young-of-the-year (Robinette, et al., 1957). Frequently the extent of this mortality and the factors causing it are not assessable. The factors affecting survival of moose calves also are not known. However, aerial sex and age composition counts are made of the moose populations in October or November, when the calves are four to five months old. Thus, if the fetus:cow ratio (the ratio of fetuses per 100 cows) is known, these counts should provide a measure of calf mortality to the date of the count.

Aerial observers cannot distinguish yearling females from female moose of other ages. Therefore, in computing a fetus:cow ratio to be used in conjunction with aerial counts from the data collected from the moose killed by trains during the winter of 1955-56, female moose of all ages, including calves, are combined with the adults. The inclusion of female calves is necessary because they are counted as adults in the following fall aerial sex and age composition counts. In computing the fetus:cow ratio only those cows of known age which were examined for pregnancy data are included. Then by including the proportion of yearlings and calves found in the sample of 146 railroad-killed female moose, a weighted fetus:cow ratio is computed. This average is 87 fetuses per 100 total females (Table 11).

The inclusion of all female calves undoubtedly causes the calculated

TABLE 11. THE WEIGHTED AVERAGE FETUS:COW RATIO FROM DATA COLLECTED WINTER 1955-56

Age Classes	No. in Sample	Per cent 146 Females	*No. in Sample of Females Examined	Per cent of Examined Females Sample	Fetuses/100 Cows in Examined Sample	Theoretical Fetus:Cow Ratio by Increments of Each Age Group
Calf	27	18	0	0	0	0
I	10	6	0	0	0	0
II and III	12	8	6	16	100	8
IV and V	32	22	14	37	121	27
VI and VII	38	26	9	23.5	100	26
VIII and IX	27	18	9	23.5	144	26
Totals	146	100	38	100		87

*Using only the data from 38 animals--8 animals of unknown age are not included.

fetus:cow ratio to be minimal, because the calves were collected from January to March, and undoubtedly considerable calf mortality occurred subsequently in the spring of 1956, a particularly severe winter and spring. Thus, since the female calves are not contributing to the reproducing portion of the female population, their over-representation in computing the weighted fetus:cow ratio acts as a depressant on the fetus:cow ratio (Table 11).

In 1956 the Railbelt-Matanuska area calf:cow ratio computed from the October counts was 38 calves per 100 cows. When this ratio is compared with the fetus:cow ratio of 87 fetuses per 100 total females, a calf mortality of 56 per cent to October is indicated. Possibly, these ratios cannot be compared directly, and several possible sources of error in making aerial sex and age counts are recognised. However, aerial counts of these moose populations have been conducted for the past seven years, and in no instance has the calf:cow ratio of a local area approached the observed fetus:cow ratio. Calf mortality of 30 to 70 per cent by October may be normal for the species, depending, of course, upon local environmental factors.

The specific factors causing this seemingly great mortality are unknown, but probably represent both pre and postnatal mortality. Only one instance of probable prenatal mortality in moose was observed (see Reproduction). Postnatal mortality factors are not well known. Black bear are thought to take numbers of moose calves in some areas (Chatelain, 1950); the bear populations, however, are not great in the

Valley areas; only two were observed on moose calving areas during 10 hours of low observational flying in the spring of 1957. Moose calves seem to be accident prone, and succumb to drowning, falls, cars, dogs, and possibly to abandonment.

Survival of moose beyond four to five months and the factors affecting their survival are not well known. Accidents, hunting, predation, and severe winters are recognized mortality factors. The effects of these factors are difficult to determine, and the magnitude of each varies from year to year. During the winter of 1955-56, 229 moose were killed by trains on the 56 miles of railroad which transect the study area. In 1957-58 only seven moose were reported killed on this same segment. The great difference is attributable to extreme variations in snow accumulations between the two winters and to a rearrangement of train schedules (Rausch, 1957).

Highway accidents are another major source of accidental kills. These accidents result in approximately 100 moose fatalities annually in the Lower Susitna Valley areas. The magnitude of the highway kill is somewhat dependent upon the severity of the winter; however, moose are killed throughout the year.

Adult moose seemingly are as accident prone as are their calves, and considerable numbers die each year as a result of falling from cliffs, breaking through thin ice, falling into construction ditches, tripping over fallen trees, and running into or becoming entangled in fences.

Hunting affects only the male population segment in Age Class I and older. The per cent removal of males varies with accessibility of the moose. In Area I, roughly 90 per cent of the males are removed, whereas in Area III few moose are taken. Poaching (illegal hunting) removes an unknown number of bulls and cows. Although the total illegal take is not known, it is considerable in some areas. At least 12 cow moose were known to have been killed during the August 20 to September 20 season of 1957, and undoubtedly many of the Valley area "homesteaders" have fresh meat throughout the winter.

Wolves and grizzly bears, the only natural predators of moose older than calves in this portion of Alaska, are both rare in the study areas. Neither are taking a significant number of moose in the study areas; no authentic reports of wolves occurring in the study areas have been received in the past two years, and only two grizzly bears were seen during the study, although bear tracks are fairly common along the areas' salmon streams.

Perhaps, hunting, accidents, and particularly severe winters, as discussed in the section on age composition, are the most important decimating factors to the moose populations studied.

WEIGHTS AND MEASUREMENTS

Peterson (1955) summarized the available weights and measurements of the four subspecies of North American moose. The Alaskan subspecies, Alces alces gigas, is represented in his data by five specimens (bulls taken from the Kenai Peninsula for museums). No weights are recorded for the Alaskan specimens.

Eighty-three moose, of Age Class Calf or above, were weighed or measured in conjunction with current moose management studies of the Railbelt and Matanuska Valley moose populations in south central Alaska (Table 12).

The weights given in Table 12 are in pounds and are self-explanatory. The measurements are in millimeters, and are defined as follows:

Girth--circumference of the body back of the forelegs, around the deepest part of the chest.

Hind Foot--heel of the calcaneum to the tip of the hoof.

Total Length--tip of the nose to the tip of the tail, excluding hair, following the body contours over the back.

Ear--notch to the tip of the ear, excluding hair.

Height at Shoulder--vertebral spine of the scapula to the bottom of the hoof.

Pelvis--crest of the ilium to the tuberosity of the ischium.

Body--metacromium process of the scapula to the tuberosity of the ischium.

TABLE 12. WEIGHTS AND MEASUREMENTS OF 83 ALASKAN MOOSE

Date	Age Class	Measurements in millimeters: Girth	Hind Foot	Total Length	Ear	Shoulder Height	Pelvis	Body	Neck	Tail	Weights in Pounds: Body	Total	Sex	Accession No. R. A. R.
May 29, 1957	Calf	655	445	1140	135	835						40	F	968
June 2, 1957	Calf	660	465	1090	140	795	220	600	240	45		48	M	969
June 5, 1957	Calf	600	420	880	125	770	175	500		40		31	F	970
June 6, 1957	Calf	630	440	1105	140	850	200	570		45		45	M	971
June 13, 1957	Calf	810	510	1190	160	960	245	680	270	60		78	F	501
June 15, 1957	Calf	610	444	842	130	864						39	?	974
June 18, 1957	Calf	720	460	1180	140	850	210					58	M	973
June 18, 1957	Calf	680	430	1040	140	840	190					53	F	972
June 24, 1957	Calf	680	472	1052	153	942	185					62	M	975
June 30, 1957	Calf		489	1155		927				51		54	M	504
July 11, 1956	Calf		533	1295	171					114		102	M	None
July 18, 1957	Calf		552	1220		1092				76		110	F	507
Kalgin Island Moose [1]														
June 18, 1957	Calf	680	430	1040	140	840	190					53	F	972
June 30, 1957	Calf	711	451	1079		863							F	972
August 11, 1957	Calf	914	533	1549		1041							F	972
June 18, 1957	Calf	720	460	1180	140	850	210					58	M	973
June 30, 1957	Calf	737	457	1117		914							M	973
August 11, 1957	Calf	990	558	1625		1117							M	973
November 15 to 20, 1957	Calf	1499	673	2108	229	1397	381	1321	267			425	F	944
November 23, 1957	Calf		673			1359		1066			210	310	M	779
November 23, 1957	Calf		711		229	1499					270		M	820
December 20, 1956	Calf										285	450	M	340

TABLE 12 (Continued)

Date	Age Class	Measurements in millimeters: Girth	Hind Foot	Total Length	Ear	Shoulder Height	Pelvis	Body	Neck	Tail	Weights in Pounds: Body	Total	Sex	Accession No. R. A. R.
January 2, 1957	Calf		622	1626		1257							F	352
January 4, 1957	Calf		635											None
January 8, 1958	Calf	1321	660	1930	216	1435	394	991		108	210	325	M	964
January 16, 1957	Calf	1575	610	1981	254	1422	381	1219	406		275	425	F	328
January 21, 1958	Calf	1626	718	1981	222	1511	445	1422	470		265	425	M	984
January 26, 1957	Calf		635								205		M	339
January 26, 1957	Calf	1473	635	1549	229	1321			330			300	F	327
January 26, 1957	Calf	1473	660									202[2]	F	334
January 26, 1958	Calf	1549	699	2007	210	1397	406	1321	394			385	F	987
January 29, 1958	Calf	1473	692	2159	215	1505	413	1232	406				M	994
January 31, 1957	Calf	1524	711		203						223		M	418
February 3, 1958	Calf	1372	718	2184	222	1397	419	1346			240	395	M	None
February 4, 1957	Calf	1524	686			1549					225	375	M	375
February 4, 1957	Calf	1422	686			1473					235		M	366
February 4, 1957	Calf	1397	610			1473					205		F	223.4
February 11, 1957	Calf		673								208		F	None
February 13, 1957	Calf	1461	686	1880	216	1575			356		268	415	F	379
February 14, 1957	Calf				216	1448					240		F	389
February 16, 1957	Calf	1270	648	1575	191	1397	318	1092	368		140	230	F	380
February 23, 1957	Calf	1524	660	1676		1461			318		205	310	F	397
February 26, 1957	Calf	1321	673	1930	216	1422	343		305		200	315	M	403
March 2, 1957	Calf	1422	673	1803	216	1499			356		235	385	F	405
March 11, 1957	Calf	1321	660	1854	216	1372			356		195	295	M	426
August 31, 1957	I			2159	241	1549					485		F	543
September 2, 1957	I	1981	749	2438	254	1651	533	1575	495			630	F	536
March 19, 1957	I	1829	813	2642	254	1753	533		508		457	669	F	428

TABLE 12 (Continued)

Date	Age Class	Measurements in Millimeters: Girth	Hind Foot	Total Length	Ear	Shoulder Height	Pelvis	Body	Neck	Tail	Weights in Pounds: Body	Total	Sex	Accession No. R. A. R.
September 2, 1957	II		800			1715					590		F	513
October 31, 1957	II	2134	813	2515		1880							F	677
March 4, 1957	II	1930	762	2134	254	1803					540	770	F	415
August 24, 1957	II		749		248	1676						843	F	559
November 26, 1957	III	1880	775		254	1753		1524	406		690	840	F	None
August 22, 1957	III	1905	737	2591	248	1727	533	1727	584	102	545	840	F	528
January 8, 1957	IV		813									870	F	420
February 4, 1957	IV	1905	838			1854					665		F	373
February 13, 1957	IV	1905	787	2438	260	1880	508		610		540	828	F	378
April 9, 1957	IV		800		248	1829					510	695	F	450
March 14, 1957	V		762	2489	254	1854			457		570		F	430
August 25, 1957	V	2032	800	2642	267	1854	584	1753	559		700	995	F	521
September 2, 1957	VI	2337	787	2692	254	1803			508			925	F	531
March 9, 1957	VI	1930	787	2337	241	1880			495		580		F	417
April 2, 1957	VI	1880	787	2718	254	1905	559	1753	584		514	800	F	448
September 16, 1957	VI	2286	806	2845	273	1880		1702	660		670	955	F	586
June 9, 1957	VI	1803	800	2692	241	1803	483		584	89	540	760	F	500
November 3, 1957	VIII	2083	826	2616		1854							F	676
February 22, 1957	IX		762								500		F	398
April 10, 1957	IX		787		260	1727					411	579	F	451
December 19, 1957	Unknown	2108	806	2794	248								F	1141
January 17, 1957	Unknown		762									908	F	344
August 21, 1957	I		775	2083	248	1536		1080		152			M	629
August 22, 1957	I	1727	737	2464	254								M	821
September 8, 1957	I	1524	762	1600							450		M	822
February 7, 1957	I		749			1753						652	M	391

TABLE 12 (Continued)

Date	Age Class	Measurements in millimeters: Girth	Hind Foot	Total Length	Ear	Shoulder Height	Pelvis	Body	Neck	Tail	Weights in Pounds: Body	Total	Sex	Accession No. R. A. R.
March 31, 1957	I	1626	800	2743	254	1753		1549	559				M	444
August 20, 1957	II		800	2642	254	1638							M	630
December 18, 1957	III		813			1778					809[3]		M	938
February 4, 1957	III										545		M	369
September 20, 1957	IV		826	2819	267	1981				127			M	587
February 16, 1957	IV		813								580		M	402
January 31, 1957	VI	2235	838			2134					780	1085	M	360
February 14, 1957	VI		826		254	2083					730		M	387
January 8, 1958	VIII	2261	838	2870	254	1930		1778	559		870	1140	M	965
November 2, 1957	Unknown	1930	787	2629	273	1880					540		M	790
February 7, 1957	Unknown	1702	762			1803					460	645	M	208.5

[1] Courtesy of Charles Parsons
[2] Starved.
[3] With antlers.

Neck--metacromium process of the scapula to the atlas.

Tail--tip of the tail, excluding hair, to the first sacral vertebra. On moose this measurement is very difficult to take accurately.

Although the present data are too few to be conclusive, it seems that few mature bulls exceed 1,200 to 1,400 pounds in total weight even in their pre-rut prime. Total weights of four bulls, and hog-dressed weights of six bulls, Age Class I and above, are presently available (Table 12). The weights of the mature bulls, Age Class III and above, are all from the winter months, a period when bulls are thin and possibly weigh 10 to 15 per cent less than during their pre-rut prime in the early fall (Skuncke, 1949). The heaviest of these individuals weighed a total of 1,140 pounds. Skeletal measurements indicated that this was a very large moose.

The maximum total weight of 17 females Age Class I and above was 995 pounds. The average total weight of 10 females Age Class II and above, collected during the fall and winter months, was 877 pounds. Cow moose do not lose weight during the breeding season in late September and early October and consequently they enter the winter in prime condition. They do, however, utilize their fat deposits gradually during the winter and by spring have lost considerable weight. The average total weight of four females above Age Class II, which were collected in late spring and early summer, was 708 pounds, roughly 20 per cent less than the average of the 10 individuals collected during the fall and winter.

The amount of weight lost by individual female moose is dependent upon a number of factors, including the severity of the winter and the quantity and quality of available winter browse. The few weights recorded here are not necessarily typical of all areas. Certainly, a greater number of individuals representing all seasonal periods and contrasting climatological and range conditions is needed before conclusions are drawn concerning average winter weight losses.

Growth

Moose calves grow rapidly during their first five or six months of life and may weigh 10 or more times their birth weight by the end of this period. Calves, which in this area are born from mid-May to early June, weigh approximately 25 to 35 pounds at birth (Rausch, 1958) and by mid-November they may weigh as much as 400 to 450 pounds.

The average of 10 calves weighed during late May and June (nine of these were weighed in June) was 50 pounds; two calves weighed in mid-July averaged slightly over 100 pounds apiece; three calves weighed in mid-November averaged 385 pounds apiece.

The growth of moose from conception through the first year of life is illustrated in Figure 8. This graph was constructed from the total length measurements of 95 moose embryos, fetuses, and calves. In this and in the subsequent figures (9, 10, and 11) in this section the individual measurements are represented by a point and the averages for the indicated periods by a circle. The curve was fitted to the averages by

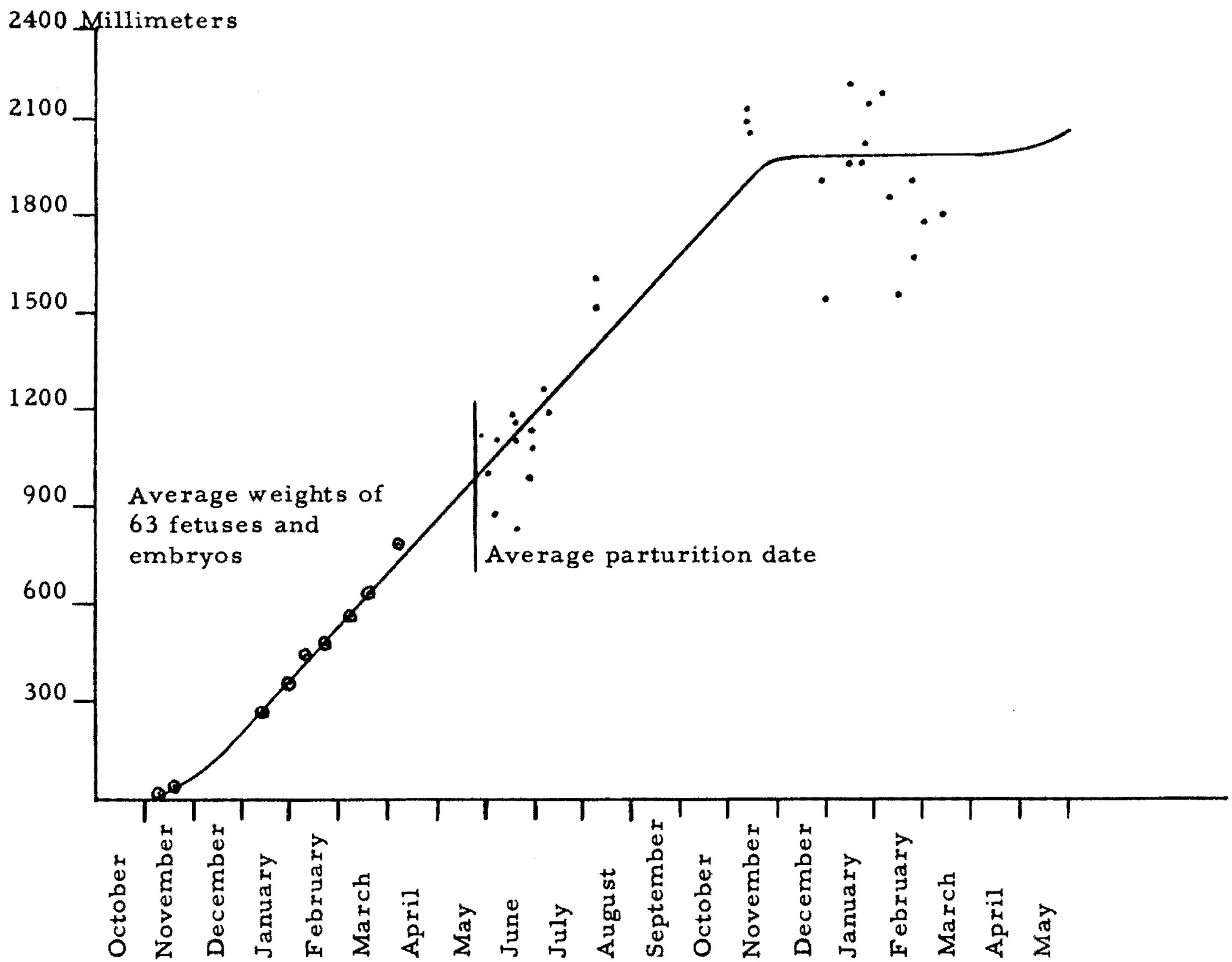

Figure 8. Growth of Alaskan moose from conception to 10 months post partum as illustrated by total length measurements of 95 embryos, fetuses, and calves.

visual inspection. The curve in Figure 8 is a generalized and tentative curve, as are those given in subsequent figures, and it is not meant to represent any biological law of growth, nor to picture detailed variations in the growth pattern.

The range of total lengths is quite great, particularly in those measurements taken during the winter months when the moose were 6 to 10 months old. The differences in total length may well reflect individual differences in rate of growth. The rate of individual growth may be affected by a number of factors of which the more obvious are the following: differences in the rate of development between the sexes and between twins and singletons; individual differences, i.e., genetic differences; and variations in local environmental conditions. At present, data illustrating these factors are meager. Skuncke (op. cit.) reports that males exceed females in total growth at the end of six months. Although weights and measurements representing the various areas are too few to be significant, there is some indication that moose vary in size from one area of Alaska to another.

Growth from the early fetal stages through the first five or six months of life is continuous, although at a progressively decreasing rate. With the onset of winter conditions in late November, growth apparently halts.

The growth of moose from birth through approximately 22 months is illustrated in Figures 9 and 10. Figure 9 is based upon total weights of 40 moose. The curve was fitted to these averages by visual

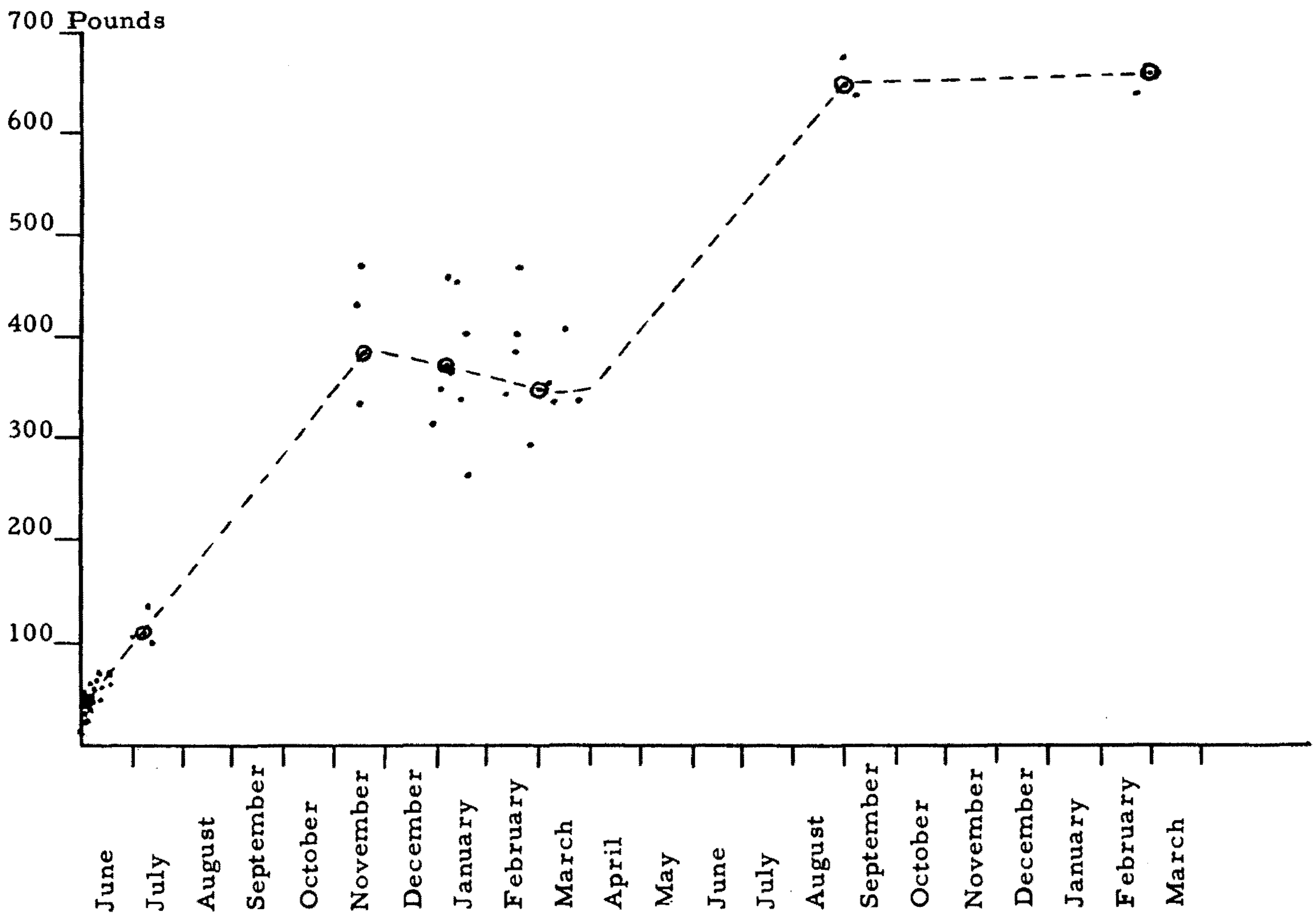

Figure 9. Growth of Alaskan moose from 1 to 22 months as illustrated by total weights of 40 individuals.

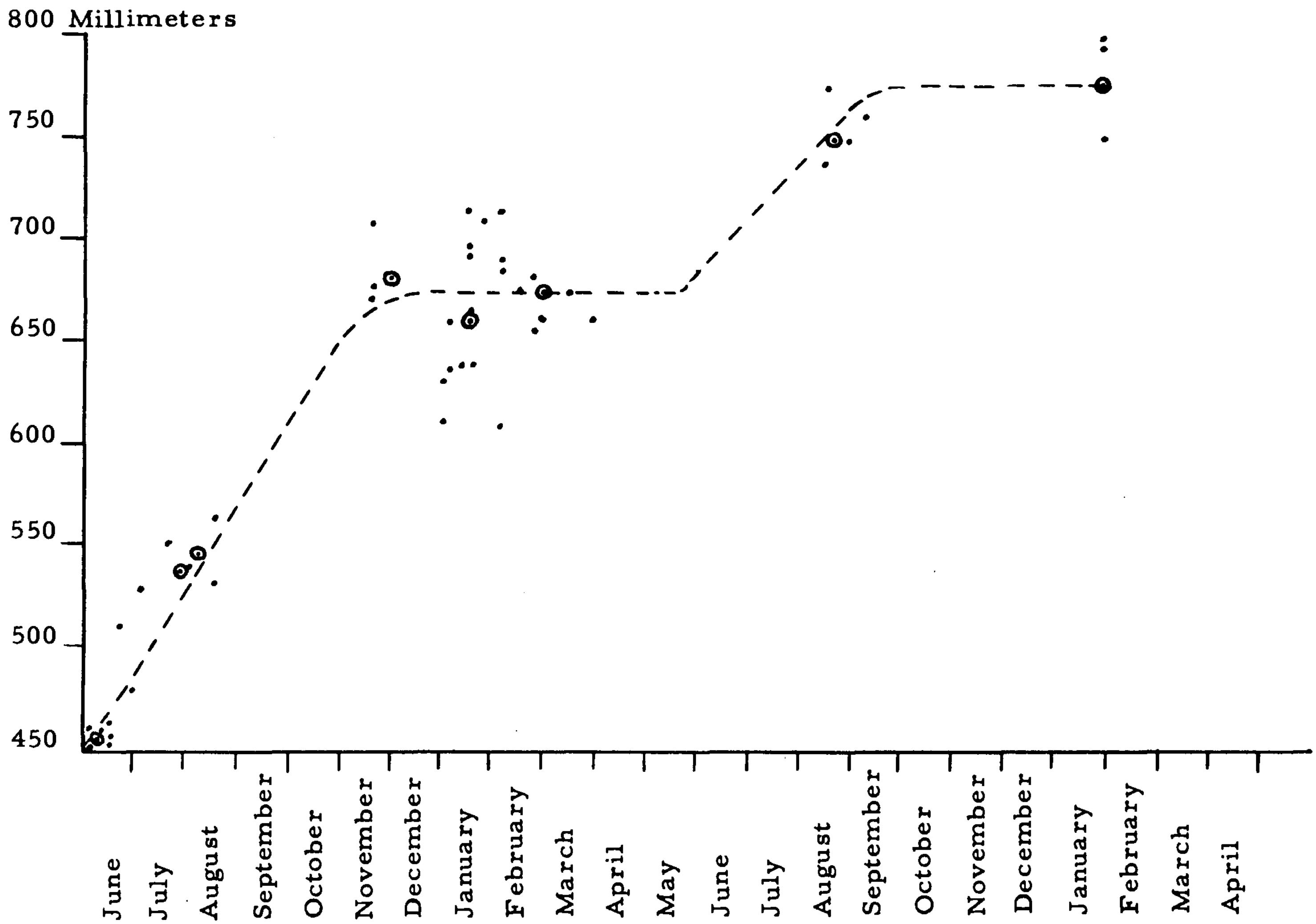

Figure 10. Growth of Alaskan moose from 1 to 22 months as illustrated by hind foot measurements of 44 individuals.

inspection. Figure 10 represents hind foot measurements of 49 moose. This curve was fitted to the biweekly averages by visual inspection.

The data represented by Figures 9 and 10 indicate that moose calves grow only during the summer and early fall. The physiological reasons for this cessation of growth are not completely understood. Cowan (1957) presents data which show a similar cessation of growth for captive black-tailed deer. The deer did not grow during the winter months regardless of the nutritional plane of the diet. Cowan postulates that the cessation of growth occurs probably as a result of endocrine changes, but he does not offer an explanation of the causative agent or stimulus which initiates the endocrine change. In the case of moose, the cessation of growth would appear to have survival value as the winter diet is frequently marginal even from a maintenance standpoint. In fact, the limited data presented in Figure 9 suggests a slight decrease in weight of calf moose as the winter progresses. Another period of relatively rapid growth commences in the spring of the moose's second year and by September or October, at 16 to 17 months of age, approximately 90 per cent of the total skeletal growth is completed. The physiological processes governing the initiation of the second period of growth are not known. However, both cessation of growth in the fall and its subsequent initiation in the spring could be related to photoperiodicity. Also, both periods of growth coincide with availability of food. In the fall the available diet is of a relatively low nutritional plane and probably would not sustain continued growth and maintenance requirements. The spring revival of growth coincides with the availability of a more nutritive diet.

Total weight continues to increase for a number of years, but apparently at a much reduced rate. Skuncke (*op. cit.*) indicates that Swedish moose grow in total weight until at least seven years of age and that bulls probably grow in total weight until ten years of age. He further states that females do not grow much after the first three or four years. The weights and measurements of the Alaskan subspecies listed in Table 12 and illustrated in Figure 11 indicate that females grow very little in either total weight or skeletal measurements beyond Age Class III.

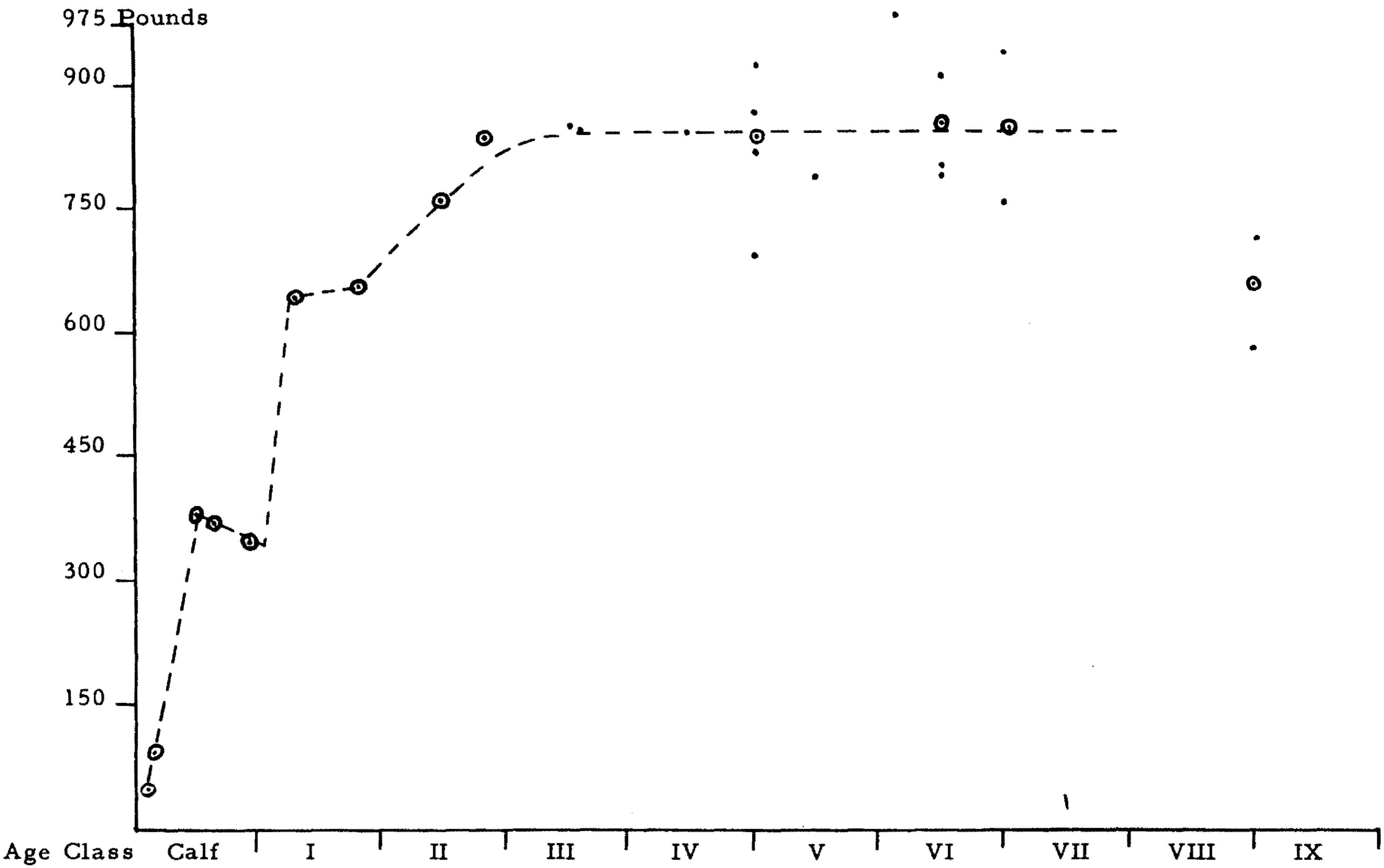

Figure 11. Growth of Alaskan moose from birth to maturity as illustrated by total weight. (Beyond Age Class II only weights of females are shown).

SUMMARY

The moose populations inhabiting the Lower Susitna Valley along with those on the Kenai Peninsula constitute Alaska's densest and most accessible moose populations.

Moose were not abundant in the Lower Susitna Valley prior to the mid-nineteen-forties, but by the late forties they were very abundant, particularly along the Alaska Railroad right-of-way between Mile Posts 172 and 228.

The moose tend to concentrate in the choice winter browse areas along the Railroad and have created two major problems: one involves the moose obstructing the Railroad and being killed by trains; the other involves the proper management of this valuable natural resource.

The present project commenced in January, 1956, through the cooperation of the Alaska Railroad and of the United States Fish and Wildlife Service. The project was designed to obtain information that would alleviate the moose _versus_ Railroad conflict, and to provide the basic biological facts necessary for proper management of the moose populations. Only the data pertinent to the latter problem have been presented here.

Male moose reach sexual maturity at the age of 16 to 18 months; female moose generally attain this development one year later, although a few breed at 16 to 18 months. The age at sexual maturity of males was determined by presence of spermatozoa in the epididymis, and by

inference from an area where yearling bulls constitute 90 per cent of the males, and the pregnancy rate of females is over 90 per cent. Sexual maturity of female moose was determined by ovarian and uterine examinations.

The period of rut extends from late August through part of November; the majority of female moose, however, conceive during late September and early October, with the peak of conception probably occurring in the first few days of October.

Moose calves are born in late May and early June, with the probable peak of parturition occurring between May 26 and 29.

Cow moose fertility, which has long been debated, was found to be high. Analysis of ten sets of ovaries collected from cows of Age Class II or older prior to ovulation revealed that all of the ovaries contained developing follicles. Examination of 98 uteri collected during the months when moose normally are pregnant revealed that 94 per cent of the females Age Class II or older were pregnant.

Data on the sex of 63 moose fetuses and 129 moose calves, age one to ten months, revealed a sex ratio of essentially 100:100. The sex ratio of moose older than calves is distorted by hunting, which by law affects only the male moose. In one relatively unhunted area, however, sex-selective mortality factors appear to affect adult males at a rate greater than adult females.

The information on population age-structure of three local moose populations indicate that the populations are different. The differences in population age-structure may reflect the effects of local climatological influences.

Mortality of moose calves during the first four to six months following birth is between 30 and 70 per cent and may be normal for the species. The specific mortality factors affecting calf moose are not known. The most important mortality factors affecting moose older than six months are severe winters, accidents, and hunting. Natural predators of adult moose are rare or absent from the study areas.

Weights and measurements of 83 moose are listed. Apparently few male moose exceed 1,400 pounds live weight. The average of 10 females Age Class II or older was 877 pounds.

Moose grow rapidly during their first two summers and may attain 90 per cent of their total skeletal growth during these two periods. Weight increment continues for a number of years.

LITERATURE CITED

Armstrong, R. A. 1950. Fetal development of the northern white-tailed deer (Odocoileus virginianus borealis Miller). The American Midland Naturalist, 43(3):650-666.

Chatelain, E. F. 1950. Bear moose relationships on the Kenai Peninsula. Transactions of the Fifteenth North American Wildlife Conference:224-234.

______________. 1951. Winter range problems of moose in the Susitna Valley. Proceedings of the Second Alaska Science Conference: 343-347.

Cheatum, E. L. 1946. Breeding season of white-tailed deer in New York. Journal of Wildlife Management, 10(3):249-263.

______________. 1949. The use of corpora lutea for determining ovulation incidence and variations in fertility of the white-tailed deer. Cornell Veterinarian, 39(3):282-291.

Cowan, I. McT., A. J. Wood, and W. D. Kitts. 1957. Feed requirements of deer, beaver, bear and mink for growth and maintenance. Transactions of the Twenty-Second North American Wildlife Conference:179-188.

Golley, F. B. 1957. An appraisal of ovarian analyses in determining reproductive performance of black-tailed deer. Journal of Wildlife Management, 21(1):62-65.

Lensink, C. J. 1955. Tentative method for aging moose. Federal Aid in Wildlife Restoration, (Alaska), 10(2):3-15.

Lonnberg, Einar. 1923. Sveriges jaktbara djur. Svenska Jordbrakets bok, Albert Bonnier. Stockholm, Haft. 1, 65 pp.

Peterson, R. L. 1955. North American moose. University of Toronto Press, Toronto, Canada, 280 pp.

Quimby, D. C. and J. E. Gaub. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. Journal of Wildlife Management, 21(4):435-450.

Rausch, R. A. 1957. The problem of railroad-moose conflicts in the Susitna Valley, 1955-56. Unpublished MS in files of U. S. Fish and Wildlife Service, Anchorage.

Rausch, R. A. 1958. Weights and measurements of moose calves. Unpublished MS in files of U. S. Fish and Wildlife Service, Anchorage.

Ritcey, R. W. and R. Y. Edwards. 1958. Reproduction in a moose population. Journal of Wildlife Management, 22(3):261-268.

Robinette, L. W., J. S. Gashwiler, J. B. Low, and D. A. Jones. 1957. Differential mortality by sex and age among mule deer. Journal of Wildlife Management, 21(1):1-16.

Skuncke, F. 1949. Algen, studier, jakt och vard. P. A. Norstedt and Soners, Forlag, Stockholm, 400 pp.

Snedecor, G. W. 1946. Statistical methods. The Iowa State College Press, Ames, Iowa. 486 pp.

U. S. Weather Bureau. 1955. Climatological data, Alaska. XLI(13): 186-196.

Winters, L. M. and G. Feuffel. 1936. Studies on the physiology of reproduction in the sheep. University of Minnesota Agricultural Experiment Station, Technical Bulletin 118, 20 pp.

______________, W. W. Green, and R. E. Comstock. 1942. Prenatal development of the bovine. University of Minnesota Agricultural Experiment Station, Technical Bulletin 151, 44 pp.