STATE OF ALASKA
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DEPARTMENT OF FISH AND GAME
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DIVISION OF GAME
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MOOSE REPORT

by

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Volume XI
Annual Project Segment Report
Federal Aid in Wildlife Restoration
Project W-17-2, Jobs 1.1R, 1.2R, 1.3R

(Printed October, 1970)

ACKNOWLEDGEMENTS

The following Alaska Department of Fish and Game and United States Fish and Wildlife Service personnel participated in scientific activities relevant to this report: D. Bromley, W. Cheney, H. Clark, D. Cornelius, J. Davis, C. P. Erskine, J. Hakala, C. Jackson, A. Johnson, P. LeRoux, G. Milke, R. Perkins, K. Pitcher, J. Sexton, N. Steen, R. Wolfe.

R. A. Rausch was instrumental in implementing all work reported here.

R. K. Seemel was responsible for all vegetation analysis work reported.

R. A. Richey contributed most sightings of collared moose.

V. Berns supplied initial radio gear and instructed us in its use.

S. Harbo consulted on design and analysis of replicate aerial count experiments.

Sincere thanks is given all the above.

TABLES

FIGURES

JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperators:	Alaska Department of Fish and Game, U. S. Bureau Sport Fisheries and Wildlife, Kenai NWR		
Project No.:	W-17-2	Project Title:	Moose Investigations
Job No.:	1.1R	Job Title:	Moose Productivity & Physiology

Period Covered: July 1, 1969 through June 30, 1970

SUMMARY

Natality, mortality and yearling recruitment within four one-square mile enclosures followed trends of nearby unenclosed populations for three seasons. On July 1, 1970, 58 moose were present within the enclosures.

Two hundred sixty-four sera, one hundred thirty whole blood specimens and one hundred seventy blood smears were analyzed for sixteen parameters reported here. Significant differences were noted in relation to age, season, reproductive status and sex of moose for certain of these parameters. Several parameters (eg: Ca, P, BUN, uric acid, cholesterol, albumin, SGOT) emerge as probably useful in determining nutritional status of moose.

Analysis of browse utilization data from 1968-69 and 1969-70 estimates winter consumption by moose at 11.4 $\pm$ 26.0 S.D. (1968-69) and 4.02 $\pm$ 9.20 S.D. (1969-70) pounds per moose per day wet weight. The present method of estimation is too insensitive for practical use.

CONTENTS

BACKGROUND

Management of moose (Alces alces) in Alaska has always relied on gross knowledge: 1) of population indices (eg: relative numbers, sex ratios, age composition, apparent natality) gained through observation (usually by air) of large numbers of animals, 2) of hunter harvest learned from reporting procedures, 3) of unusual mortalities ("die-offs") when noticed and, 4) of occasional crude and subjective observations of browse conditions. The state's expanding human population makes these methods, by themselves, obsolescent for various biological and political reasons.

For example, on the Kenai Peninsula, an extensive (more than 350,000 acres) burn occurred in 1947, with a subsequent striking increase in the numbers of moose present. By the late 1950's, numbers seemed to have stabilized; yet the predominately birch seral type was noticably browsed in very few areas, and hedged in even fewer places. Moose production had fallen behind browse production. No "die-off" had been recorded, browse was not (to the superficial observer) over-used, hunter harvest was low in relation to the moose population size, and most (more than 90%) cow moose were pregnant in fall and early winter. Less-than-obvious factors were at work. More sophisticated knowledge of and means of quantifying moose physiological and vegetation parameters were needed.

Situations requiring such knowledge are not localized on the Kenai Peninsula. The information is needed for solving present and future problems wherever moose occur in the state. The Tanana River flats near Fairbanks support a moose population similar in density to that in the Kenai 1947 burn. In spring 1965, gross signs of loss of condition were observed, few viable calves were produced, and collections revealed severly undernourished calves. Classical symptoms of severly browsed shrubs and high moose densities were present, but more specific analysis was impossible given the then-and-present state of knowledge. At about the same time (1962 through 1965) moose numbers apparently declined markedly in the Nelchina Basin: no explanation but severe winters was possible. Matanuska Valley populations, the only ones in the state even possibly manipulated by hunting, fluctuate in ways that could be better understood and predicted by more specific knowledge of moose-habitat interrelationships than is currently available.

The overall project objective of jobs carried out at the Kenai Moose Research Center is to obtain a more thorough and specific knowledge of how moose affect vegetation and how vegetation affects moose.

Research dealing with the above objective has been slight. Most work has involved a population approach to learning productivity, mortality and recruitment, often by aerial counts (eg: Denniston 1956, Pimlott 1959, Spencer and Hakala 1964, Knowlton 1960, Rausch and Brattlie 1965, Simpkin 1965, Rausch and Bishop 1968, Bishop 1969). Fewer studies have used physiological or behavioral approaches to learning productivity (eg: Rausch 1959, LeResche 1968, Houston 1968, Markgren 1969). No productivity records for individual moose over more than one season appear in North American literature, although Soviet domestication work at Pechora-Ilych Reservation (Knorre 1961) has undoubtedly gathered such information.

Bone-marrow studies have been done with different degrees of sophistication and success for years (cf: Cheatum 1949, Bishoff 1954, Greer 1969 and Neiland 1970). Our present studies are but an adjunct to original work by Neiland and Pitcher and presented by Neiland (1970).

Blood studies of moose have been few and superficial and only sometimes related to nutrition. Braend (1962) considered blood groups in moose, Nadler (1966) studied serum proteins and transferrins, and Houston (1969) analyzed several serum parameters from 13 moose. More thorough nutrition-related studies have been carried out on other Cervidae. Herin (1968) reported 14 blood parameters for 39 elk (Cervus canadensis). Kitts et al (1956) related age and nutrition to hematological values in black-tailed deer (Odocoileus hemionus c.). More recently, Seal and Erickson (cf: 1969) have begun quite sophisticated blood studies of several large mammals.

Estimation of food production and utilization by moose has been attempted several times, but never with known numbers of moose (cf: McMillan 1950, Bassett 1951, Harry 1957, Knowlton 1960). Bishop (1969) reported on the initial stages of the MRC work in this area.

Isolated samples of moose milk have been analyzed by Cook et al (1970) and Glass et al (1967). No serial analyses are reported, although Knorre (1961) reported milk yield over several months for a domesticated moose.

Oestrus periods have been studied only indirectly through collections of reproductive tracts and measurments of fetuses (cf: Rausch 1959).

Nutritional analysis of browse species and nutritional studies of Cervidae have reached some degree of sophistication. Cowan et al (1950) related nutritional values of browse to plant succession in British Columbia. Verme (1962, 1963) studied nutrition-related growth and mortality in white-tailed deer (Odocoileus virginanus) fawns, and Murphy and Coates (1966) reported "effects of dietary protein on deer".

OBJECTIVES

To measure natality, mortality and general condition of moose within four one-square mile enclosures.

To establish baselines by season, age and sex for the following serological and hematological parameters in moose:

A. calcium
B. inorganic phosphorus
C. glucose
D. urea nitrogen (BUN)
E. uric acid
F. cholesterol
G. total protein
H. albumin
I. albumin/globulin ratio
J. alpha-1, alpha-2, beta and gamma-globulins
K. bilirubin
L. alkaline phosphatase
M. lactic dehydrogenase (LDH)
N. glutamic oxalacetic transaminase (SGOT)
O. hemoglobin
P. hematocrit
Q. white blood cells
R. differential cell count (including segmenters, lymphocytes, eosinophils, monocytes, basophils)

To estimate browse production and utilization and quantitatively and qualitatively estimate consumption of all plant material by moose.

To continue other objectives that were either minor (subordinated to the above) or inactive during the current reporting period. These include:

A. Serial analysis of milk from the same individual animal.
B. Determination of oestrus onset and the number of oestrus periods during the breeding season.
C. Nutritional analysis of browse species.

PROCEDURES

General Description of the Moose Research Center Facility

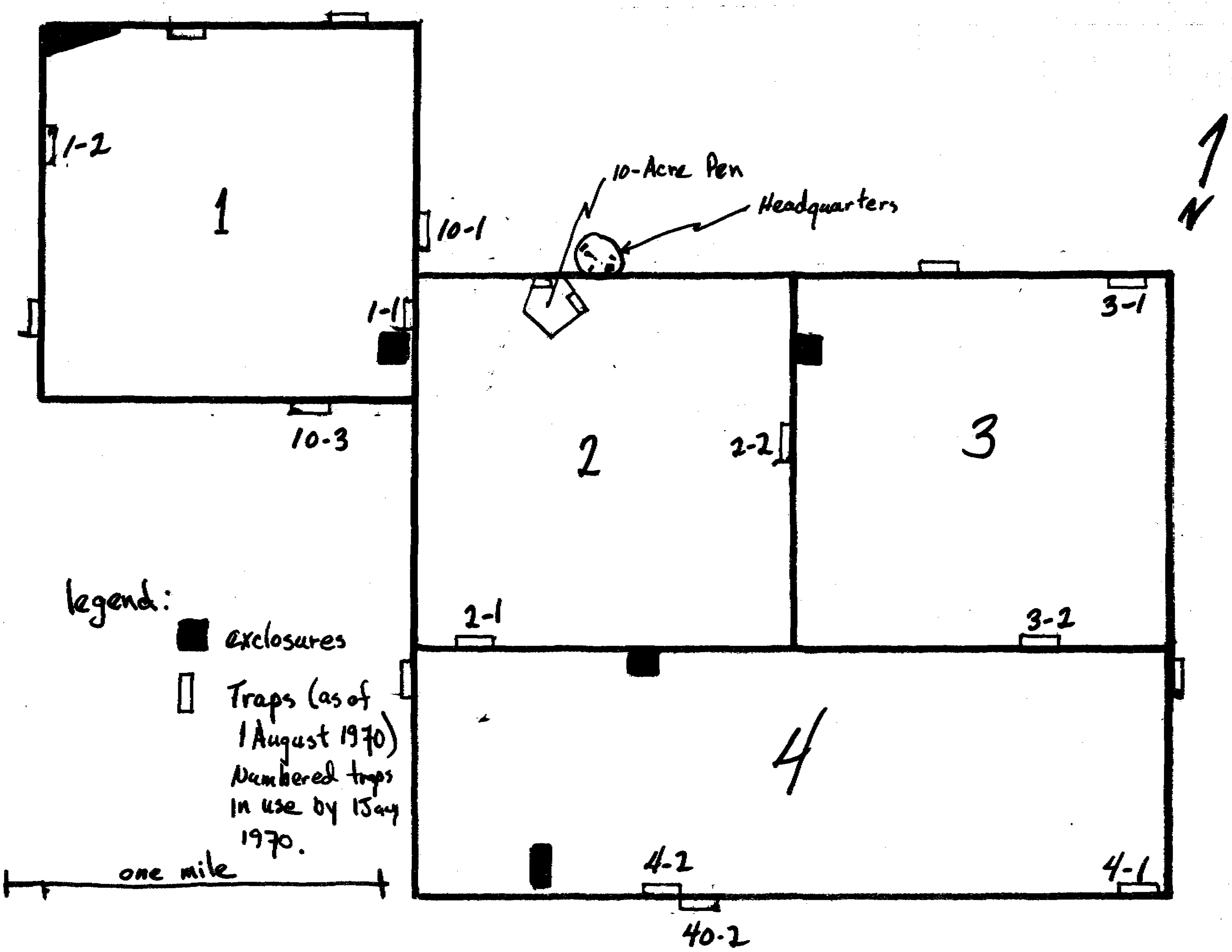
The Kenai Moose Research Center comprises four one-square-mile enclosures located in the area of the 1947 burn near Kenai, Alaska. The enclosures contain representative vegetation of both burned (regenerative: predominately birch *Betula papyrifera* and white spruce, *Picea glauca*) and remnant (mixed birch-spruce-aspen, *Populus tremuloides*) stands. Marshland typical of summer range is included as are well-drained hillocks supporting winter browse-species.

The entire area has been type-mapped into eleven vegetation types, and soil profiles of representative types have been completed. One hundred forty permanent plant-succession measuring plots have been installed subjectively (five in each pen for each of seven major vegetation types), and each has been read once. A modified Daubenmire (1959) canopy estimate is employed. Eight hundred forty permanent browse production/utilization plots have been established randomly within habitat types and these have been used to measure production (once within two of the four pens) and use (three times in two pens, once in two other pens). Twig-count and clipping methods are employed. Five five-acre exclosures are present, at least one within each enclosure.

Eleven fenceline traps were constructed during the reporting period, as was a 10-acre holding pen for tame/experimental animals. Fig. 1 is a generalized map of the facility showing traps, exclosures, etc.

The log headquarters building sleeps eight, and is accessible by road during dry seasons. Two-mile-long Coyote Lake provides access by float or ski plane. The Center may be reached by light plane from Anchorage in one-half hour.

Figure 1: Diagramatic layout of Kenai Moose Research Center.



Populations of moose within the enclosures as of February 1, 1970, five months after enclosing pens 3 and 4, were:

Pen	Cows	Calves	Bulls	Total
1	5	0	2	7
2	9	1	2	12
3	7	4	1	12
4	11	5	2	18
	32	10	7	49

It is planned to leave pens 1 and 2 unmolested in terms of moose numbers, allowing the populations to increase, decrease, or remain constant as they will. Pen 3 will be retained at its present population level and sex structure, as representative of extra-pen populations in this area. Pen 4 will be stocked with as many as 50 moose (four to five times "normal" density).

Table 1 is a history of major events in construction of the facility and provides reference as to timing of events leading to the current description.

Mortality and natality within pens is measured by daily ground observations, periodic aerial observations, trapping and use of radio-tracking devices. General condition is estimated in trapped animals by methods described below.

Blood values are determined from serum and whole-blood samples obtained from trapped and hunter-killed moose and animals immobilized for marking outside of traps (Job 3). Table 2 lists sources of blood material.

Blood is obtained from live immobilized animals in sterile evacuated containers by jugular venepuncture. Four or five cc of whole blood is preserved with EDTH and a thin smear is made; serum is secured by centrifugation of cooled and clotted blood. Serum is separated into a 1) a NaF tube (1.5-2 cc) for glucose determination and 2) a 4-5 cc untreated sample for other parameters.

Analyses are performed by Alaska Medical Laboratories (Anchorage) using a "Technicon Autoanalyzer SMA-12", standard hematological techniques and electrophoresis.

Bone marrow is analyzed by K. Pitcher using methods described by Neiland (1970). Marrow analysis to date is done only when an entire femur is collected from a dead moose. Weights of moose within pens are obtained using a boom truck or tripod.

Table 1. Chronology of establishing the Kenai Moose Research Center.

June 1966:	Construction begun.
September-October 1967:	Browse production estimated in Pens 1 & 2. Successional plots established and read in Pens 1 & 2.
January 1967:	Pens 1 & 2 enclosed.
January 1968:	Moose in Pens 1 & 2 collared.
April 1968:	Browse utilization estimated in Pens 1 & 2.
1968:	Yearling bull introduced into Pen 1.
April 1969:	Browse utilization estimated in Pens 1 & 2.
June 1969-January 1970:	Eleven traps constructed in all pens. Blood collections begun.
June-July 1969:	Successional plots established and read in Pens 3 & 4.
August 1969:	Pens 3 & 4 enclosed.
January-February 1970:	Numbers of moose in Pens 3 & 4 established. Replicate count experiments conducted.
April 1970:	Browse utilization estimated in all 4 pens.

Table 2. Sources of moose blood for analysis: June 1969-June 1970.

Source	NUMBER OF SPECIMENS Serum	Whole Blood	Slides
Trapping at Moose Research Center:			
Pen 1	7	5	5
Pen 2	21	10	10
Pen 3	8	7	7
Pen 4	17	12	12
Outside pens	14	9	9
Total Moose Research Center	67	43	43
Hunts:			
GMU 15C	32	26	49
15B	13	6	21
14A	39	26	42
14B	14	6	9
Total hunts	98	64	121
Tagging:			
Bottenintnin Lake	38	23	6
Moose River Flats	61	0	0
Total tagging	99	23	6
Totals	264	130	170

Browse production and utilization and succession are estimated using methods previously described in detail (Bishop 1969). A canopy-cover method after Daubenmire (1959), employing exclosures, is used for successional measurements and a twig-count method with clipping is used for production and utilization estimates. During this reporting period successional plots were established and read in Pens 3 and 4, and use was estimated in all old plots in Pens 1 and 2 and newly established plots in Pens 3 and 4.

Milk was analyzed by Dr. B. E. Baker at McGill University, using reported (Cook et al 1970) methods.

FINDINGS

Productivity and mortality within pens: Table 3 presents raw tagging, breeding, and mortality data for all moose within the enclosures. Table 4 summarizes the data in terms of numbers calving and dying. Table 5 calculates natality, yearling recruitment and change in population size for penned and unpenned populations. Fig. 2 compares trends of natality and recruitment inside and outside the pens.

Excluding Pen 1 during the period (1968-69) when it had no breeding bull, calves present in the pens in June averaged 51 per 100 cows of breeding age (3 years or older at birth of calf). The best data for the general 15A population, from USFWS files of aerial counts flown by R. Richey, show a June average of about 44 per 100 adult cows (ca: 1045 of ca: 2358, estimated). The penned and unpenned calf productions are statistically equivalent. Further, Fig. 2 illustrates that yearly trends for 1968, '69 and '70 parallel one-another within and without the enclosures.

Yearling recruitment presents a very similar picture. Mean spring recruitment was 17 yearlings: 100 adult females (ca: 417 of ca: 2454) outside and 18-21% (14-16 of 77) inside the pens. Statistically the values are equivalent. That yearly values parallel each other in the enclosed and wild populations is evident from Fig. 2.

At this early stage of the MRC project, then, population responses within the pens at least approximate those outside. Although we cannot ignore that our experimental animals do differ from wild populations by being confined within one-square-mile areas, present data suggest that there is little effect on productivity due to fenced conditions.

Considering adult mortality within the pens, Tables 4 and 5 show an overall net loss of only 2% within the pens over the 2 years. Thirteen percent were added to a base of 15 adults from June 1968 to June 1969; whereas; 10% were lost from 35 adults the following year. These calculations do not include animals added or removed experimentally.

From June 1968 through June 1970, nine adults and seven calves died of apparently natural causes within the pens. In addition, one adult female died of calving complications shortly after being introduced into the pens.

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

Moose#	Sex	Event	Date	Age	Circumstances
			PEN 1		
1	F	Tagged	January 1968	4+ years	Helicopter; not with calf
		Pregnant	January 1968		Palpation
		With 2 calves	7 June 1968	5 years	
		With 1 calf	17 June 1968		
		Escaped into pen 2 with 1 calf	4 September 1968		
2	F	Tagged	January 1968	4+ years	Helicopter; not with calf.
		With 1 calf	4 June 1968	5 years	Observed
		Escaped into pen 2 with 1 calf			
3	F	Tagged	January 1968	5+ years	Helicopter; not with calf
		Pregnant	January 1968		Palpation
		With 1 calf	17 June 1968	6 years	Observed
		With no calf	11, 14 October 1968		Observed
		With no calf	2, 11, 12, 14 June 1969	7 years	Observed and trapped
		Radio installed	14 June 1969		Trapped
		Radio removed	20 August 1969		Trapped
		In oestrus	15 October 1969		Trapped
		With 1 calf	2 July 1970	8 years	Observed
		Lactating, last seen	28 July 1970		Trapped
4	F	Tagged	January 1968	15+ years	Helicopter; not with calf
		With no calf, does not appear pregnant	5 June 1968	16 years	Observed
		Dead, not pregnant	18 May 1969	17 years	Apparent cause: old age
5	F	Tagged	18 January 1968		Helicopter; not with calf
		Last seen	18 January 1968		Tagging

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

Moose#	Sex	Event	Date	Age	Circumstances
			PEN 1		
6	F	Tagged	January 1968	10+ years	Helicopter; not with calf
		With calf	22 October 1968	11+ years	Observed
		With no calf	2,4,11,12 June 1969	12 years	Observed, trapped,
		Weight 910 lbs.	12 August 1970		Trapped
		With one calf			Trapped
		Calf tagged	23 July 1970	13 years	Trapped, weight 820 lbs.
		No calf observed	27 July 1970		Observed
8	F	Tagged	24 January 1968	Calf	Helicopter
		Dead	2 February 1968		Killed during tagging
10	F	Tagged	January 1968	Calf	Helicopter
		With no calf	19 June 1969	2 years	Observed
		With one calf	27 July 1970	3+ years	Observed
R70-8	F	Tagged, radio installed	10 July 1970	2 years	Trapped
		Last seen	20 July 1970	2+ years	Observed
Un-collared	F	5 Observations	21 May 1969 through 30 June 1970		Observed
		With one calf	27, 28 July 1970		Observed
43	M	Tagged & put into pen 1	7 June 1968	1+ years	Helicopter immobilization
		Apparently did not successfully breed	May-June 1969	1+ yr	No calves in pen 1
		Bred successfully		2+ yr	Calves in Pen 1,May-June 1970
		Last seen	June 1970	3+ years	Observed
35	M	Tagged	28 May 1970	2 years	Trapped
		Weight 605 lbs.	17 July 1970	2+ years	Trapped

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
1	F	Escaped into pen 2			
		with one calf	4 September 1968	5+ years	
		With no calf	10 October 1968		Observed
		With no calf	15 July 1969	6+ years	Observed
		Weighed 675 lbs.	5 September 1969		Trapped
		With no calf	10 June 1970	7+ years	Trapped
		Last seen	22 June 1970		Observed
2	F	Escaped into pen 2			
		with one calf	4 September 1968	5+ years	
		With one calf	22 October 1968		Observed
		Calf not seen	21 April 1969		Observed
		With no calf	30 May, 7 July 1969	5 years	Trapped
		Radio installed	13 August 1969		Trapped
		Not pregnant	28 May 1970	6 years	Trapped
		No calf			
		Last seen	29 June 1970		Observed
7	F	Tagged	January 1968	4+ years	Helicopter; not with calf
		With no calf	18 June 1968	5 years	Observed
		With one calf	9 July 1969	6 years	Observed
		With 1 calf; weight 710 lbs.	29 July 1969		Trapped
		In oestrus, with 1 calf	23 September 1969	6+ years	Trapped
		With no calf	26, 27 February 1970		Helicopter; observed
		Not pregnant, with no calf	4 June 1970	7 years	Trapped
		Radio installed	4 June 1970		Trapped
		Last seen	29 June 1970		Observed

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
9	F	Tagged	January 1968	5+ years	Helicopter; with one calf
		With no calf	5,17 June 1968	6 years	Observed
		With 2 calves	11 June 1969	7 years	Observed; calves tagged
		With 1 calf	12 June 1969		Tagging-induced mortality
		With no calves	10 July 1969		Tagging-induced mortality
		Breeding(?)	31 October 1969	7+ years	With #45 male
		With no calves	4, 25 June 1970	8 years	Trapped, observed
		Last seen	25 June 1970		Observed
11	F	Tagged	January 1968		Helicopter; not with calf
		With no calf	21 May, 10 October 1968		Observed
		"Especially" poor condition	1 May 1969		Observed
		With no calf	1 July 1969		Observed
		In oestrus	24 September 1969		Trapped
		Last seen	26 January 1970		Observed
12	F	Tagged	January 1969	6+ years	Helicopter; not with calf
		Not with calf	21 May 1968	7 years	Observed
		Not with calf	18 February 1969	7+ years	Observed
		Lost, observed alive	1 May 1969	8 years	Observed
		Found dead	7 July 1969	8+ years	Died 3-6 July
	Autopsy:	Massive hemmorage left of rib cage; dead along fenceline			
		Lactating			
		Flaccid uterus			
		Weight: 610 pounds			
		Conclusions: Death perhaps due to combination of poor condition and hitting fence			
13	F	Tagged	January 1968		Helicopter; with 1 calf
		Last seen	14 June 1968		With 1 yearling

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
14	F	Tagged	January 1968	7+ years	Helicopter; with 1 calf
		With no calf	4 October 1968	8+ years	Observed
		With 1 calf; wt. 580#	30 July 1969		Trapped
		Found dead	August 1969	9+ years	Drowned in hole
16	F	Tagged	January 1968	9+ years	Helicopter; with no calf
		With no calf	18 June 1968	10 years	Observed
		With no calf	9 July 1969	11+ years	Observed
		Hock tumor & displasia	3 August 1969		Observed
		Last seen	26, 27 January 1970	11+ years	Observed from helicopter
17	F	Tagged	January 1968	Calf	Helicopter
		Found dead	25 April 1968		Dart in carcass
52	F	Tagged	23 July 1969	2+ years	Trapped
		With 1 calf	18 June 1970	3 years	Observed
R70-2	F	Tagged	22 May 1970	3 years	Trapped
		Lactating; wt 635#	17 July 1970		Trapped
R70-4	F	Tagged & introduced into pen 2 with 1 calf	23 May 1970		Trapped
		Deserts calf	23 May 1970		Trapping-induced desertion
		Last seen	29 June 1970		Observed
R70-5	F	Tagged, introduced into pen 2, radio installed	24 May 1970		Trapped
		Died giving birth	27 May 1970		Twin fetuses; one breech presentation

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
Un-collared	F	Observed	1 June 1969	2 years(?)	Observed
		6 observations	Through 25 May 1970		Observed
		With 1 calf	8 June 1970	3 years(?)	Observed from helicopter
Un-collared calf	?	With #7 Female	Through 23 September 1969	4 months	Observed
		With #11, #1, #2 & also	25 September 1969		Observed
		alone at salt block	28 December 1969	7 months	Observed
		Not seen during aerial counts	26-27 January 1970	8 months	Not observed from helicopter
		Found dead near salt block	8 June 1970	7-8 months	Dentition suggests 4-9 months of age
3995	F	Tagged	January 1968	5+ years	Helicopter; with no calf
		Dead	Smelled: 2 July 1969 Found: 8 July 1969	7 years	No autopsy possible
15	M	Tagged	January 1968	2+ years	Helicopter
		Last seen	10 October 1968	3+ years	Observed
4250	M	Tagged	January 1968	Calf	Helicopter
		Last seen	January 1968		Tagging
360	M	Observed	23 July 1969	2+ years	Observed
		Breeding(?)	3,14,15 October 1969	2+ years	Observed with adult females
		Bred successfully	Fall 1969	2+ years	At least 2 calves in pen 2
		Last seen	29 June 1970	3 years	Observed
450	M	Tagged	21 October 1969	1+	Trapped-no antler development
		Last seen	5 April 1970	1+	Trapped

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 3

Moose #	Sex	Event	Date	Age	Circumstances
5050	F	Tagged; with no calf	August 1969	2+ years	Trapped
		Killed; in oestrus	23 October 1969	2+ years	Overdose of M50-50 diprenorphrine
20	F	Tagged; with 1 calf	6 August 1969	9+ years	Trapped
		With 1 calf	27 February 1970	9+ years	Observed from helicopter
		Last seen; with 1 yearling, no calf	29 June 1970	10 years	Observed
26	F	Tagged; with 1 calf	23 September 1969	8+ years	Trapped
		In oestrus	29 October 1969		Trapped
		With no calf	26,27 January 1970		Observed from helicopter
		Killed	19 May 1970	9 years	Overdose M-99 Etorphine
		Autopsy: One fetus Total weight - 600 lbs. Weight less fetus & fetal membranes - 560 lbs.			
27	F	Tagged	26 September 1969	3+ years	Trapped
		With 1 calf	8 October 1969, 27 January 1970		Trapped & observed from helicopter
		With no calf; not lactating	10 July 1970	4+ years	Trapped
28	F	Tagged; lactating	6 October 1969	7+ years	Trapped
		In oestrus			
		With no calf	26,27 January 1970		Observed from helicopter
		With 1 calf; Weight 760 lbs.	17 July 1970	8+ years	Trapped

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

Moose #	Sex	Event	Date	Age	Circumstances
			PEN 4		
22	F	Tagged, with calf	August 1969	4+ years	Trapped
		With 1 yearling	25 May, 8 June 1970	5 years	Observed
		With no calf; not lactating	17 July 1970	5+ years	Trapped
23	F	Tagged	4 September 1969	11+ years	Trapped
		With 2 calves			
		In oestrus with 2 calves	29 October 1969		Trapped
		Found dead	13 April 1970	11+ years	
		Autopsy: No fat Flaccid vascularized empty uterus			
24	F	Tagged, no calf seen	August 1969	7+ years	Trapped
		With 1 calf	26 January 1970		Observed from helicopter
		With 1 calf	25 May, 2 July 1970	8 years	Observed
25	F	Tagged; with 1 calf; weight 920 lbs.	5 September 1969	10+ years	Trapped
		With one calf	29 December 1969		Trapped
		Seen alive; with no calf	26,27 February, 4 February		Observed from ground & helicopter
		Found dead	20 July 1970	11+ years	Dead bbefore 1 June, cause unknown
29	F	Tagged; with 1 calf	14 October 1969	5+ years	Trapped
		In oestrus	14 October 1969		Trapped
		Last seen alive	21 October 1969		Trapped
		with 1 calf counts	26 January, 4 February 1970		
		Found dead	23 April 1970	5+ years	Not pregnant; dead more than 4-6 weeks in sitting position

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
31	F	Tagged with 1 calf	12 August 1969	5+ years	Trapped
		With 1 calf	29 December 1969		Observed
		Calf not seen	26 January 1970		Observed from helicopter
		Calf born	25-28 May 1970	6 years	Observed
		Last seen with calf	22 June 1970	6+ years	Observed
3444	F	Tagged	11 December 1969	13+ years	Trapped
		Last observed	26 January 1970		Observed from helicopter
R70-3	F	Tagged	20 May 1970		Trapped
		One calf born	22-23 May 1970	3 years	Observed
		Last seen	29 June 1970	3+ years	Observed
A60	F	Tagged; no calf seen Not lactating Weight 840 lbs	17 July 1970		Trapped
36	F	Tagged; lactating, calf tracks seen	23 July 1970		Trapped
2 Uncollared	F	Various observations	October, 1969-June 1970	Adult	Observed
Uncollared (2369?)	F	3 Observations with #7 male (2269)	26-27 January 1970	<1 year	Observed from helicopter
		4 observations	Through 28 May 1970		Observed
		Darted, escaped trap	4 June 1970	1 year	Trapped
		Last seen with #7 Male	10 July 1970		Observed

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1970

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
NB		3 dead calves/short yearlings were discovered in Pen 4: one died on 14 February 1970 and was discovered that day. One apparently died during winter before 22 April 1970 near the carcass of #29 Female. The third died probably during early April 1970.			
21	M	Tagged	August 1969	1+ years	Trapped
		Last seen	2 June 1970	2 years	Observed
44	M	Tagged; large staph infection left buttock	9 October 1969	1+ years	Trapped
		Not seen during aerial counts	26 January-4 February 1970		
7 (2369?)	M	Tagged	4 June 1970	1 year	Trapped
		Last seen	10 July 1970		Observed
38	F	Observed	26,27 January 1969		Observed from helicopter
		Tagged; not lactating			
		Observed	26,27 January 1969		Observed from helicopter
39 (A-26)	F	Tagged; with 1 calf	28 July 1970		Trapped
Un-collared	F	Observed; with 1 calf	26,27 January 1969		Observed from helicopter
		Calf may have been with #38 or #39			
60	M	Breeding	6-8 October 1969		3 observations with adult female
		Bred successfully	Fall 1969		At least 3 calves in Pen 3
		Tagged	15 May 1970		Trapped
		Last seen	23 July 1970		Trapped

Figure 2: Comparison of calf and yearling crops within moose exclosures and in outside population (Unit 15A).

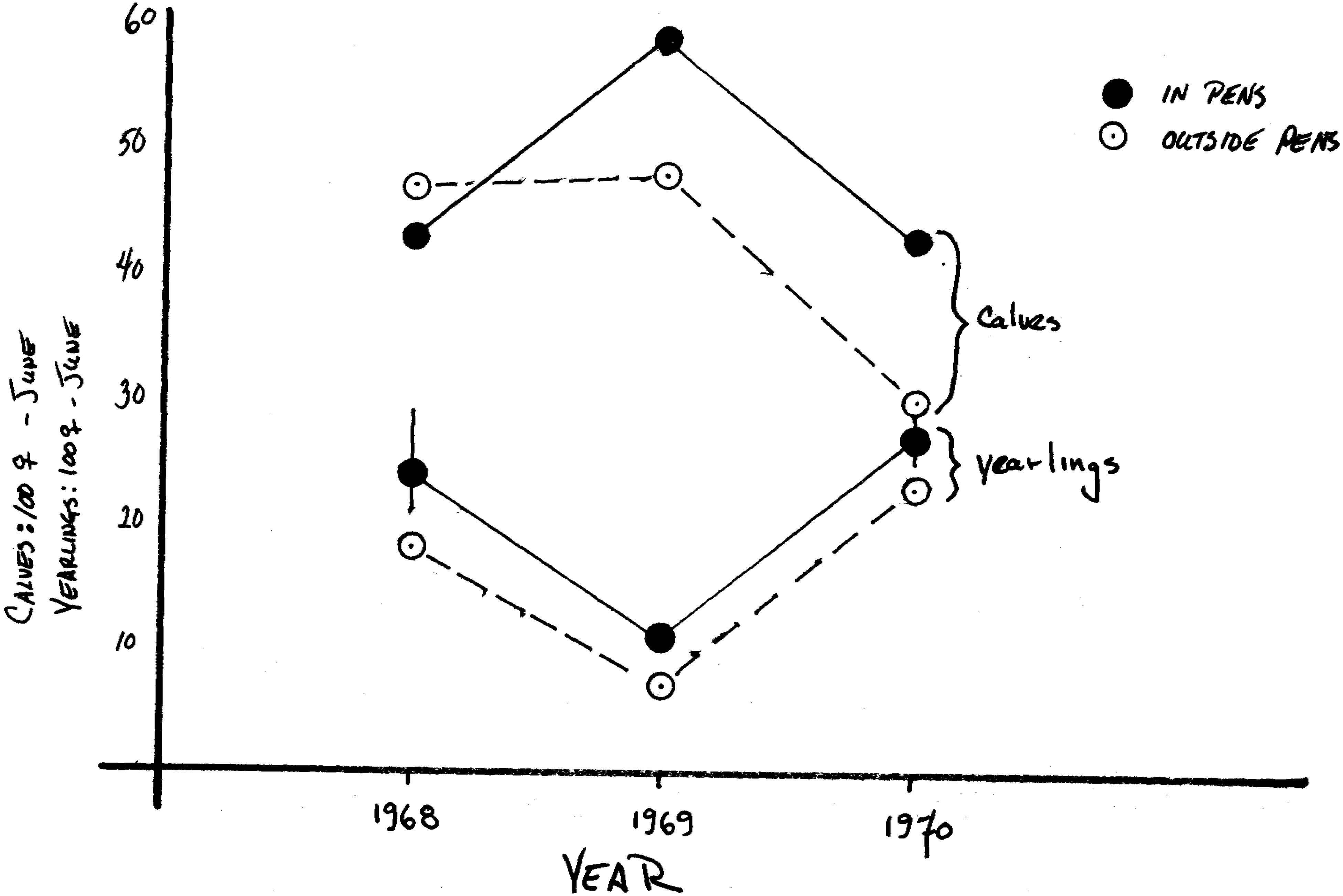


Table 4. Moose natality, mortality and recruitment in four one-square mile enclosures.

	Adult FF	Adult (MM)	Calves	Calves Lost	Yearlings Recruited	Adults Died	Net Gain (+) or Loss (-) of Adults (discounting experimental manipulation)
PEN 1							
January 1968*	6	(0)	1				
June 1968	6	(1)**	5		1		
June 1969	4***	(1)	0		2		
June 1968-June 1969				1***	2	1	+1
June 1970	5	(2)	4				
June 1969-June 1970				0	0	0	0
PEN 2							
January 1968*	8	(1)	3				
June 1968	8	(1)	1		4***		
June 1969	11***	(1)	4		1		
June 1968-June 1969				0	1	3	+1
June 1970	11****	(2)	3		0		
June 1969-June 1970				4	0	2°°°	-1
PEN 3							
August 1969	8	(1)	4		0		
June 1970	6°	(1)	2°°		3	2 (killed)	
August 1969-June 1970				1	3		0
PEN 4							
August 1969	12	(2)	10		1		
June 1970	9	(1)	4+		4-5		
August 1969-June 1970				5-6	4-5	4	-3

* Ignoring tagging mortality
** Introduced into pen
*** 2 Calves + 2 cows escaped into Pen 2 Sept. 1968
**** One adult female introduced May 1970
° 2 Adult females killed
°° One killed female contained 1 fetus
°°° One adult trapped in man-made hole

Table 5. June calf crops and yearling recruitment in Moose Research Center enclosures.

Year	Calf Crop Calves/100 F	(No. F)	Yearling Recruitment Yrlgs/100 F	(No. F)	Population (Adult) % Gain/loss	
Pen 1						
1968	83	(6)	17	(6)		
1969	0	(4) (no breeding bull)	50	(4)	+17%	(6)
1970	100	(4)	No recruitment		No change	(7)
$\bar{x}$ (not incl. 69-70)	92		34		+17%	
Pen 2						
1968	12.5	(8)	25-38	(8)		
1969	50	(8)	9	(11)	+11%	(9)
1970	30	(10)	0	(11)	-8%	(12)
$\bar{x}$	31		9-14		No change	
Pen 3						
1969 (August)	50	(8)	0	(8)	No data	
1970	29	(7)	38	(8)	No change	(6)
$\bar{x}$	40		19		No change	

Table 5. June calf crops and yearling recruitment in Moose Research Center enclosures.

Year	Calf Crop Calves/100 F	(No. F)	Yearling Recruitment Yrlgs/100 F	(No. F)	Population (Adult) % Gain/loss	
Pen 4						
1969 (August)	83	(12)	8	(12)	No data	
1970	45+	(9)	44-56	(9)	-21%	(14)
$\bar{x}$	64+		28-32		-21%	
All Pens						
1968	43	(14)	21-29	(14)		
1969	59	(27)	11	(35)	+13%	(15)
1970	43	(30)	25-29	(28)	-10%	(39)
$\bar{x}$	51	(71)	18-21	(77)	-02%	(54)
Unit 15A (Aerial counts by Richey (unpublished) and LeResche)						
1968	47	(1520)	18(est.)	(1520)		
1969	48	(438)	7(est.)	(438)		
1970	ca:30	(ca:500)	23	(496)		
$\bar{x}$	ca:44(est.)		17	(2454)(est.)		

Table 6 lists dead animals and causes of death where known. Few generalizations can be drawn from the scanty data; however, every undecomposed carcass found, as well as those of the two females killed, was in generally poor condition.

Table 7 lists extracted fat in percent of wet weight in femurs collected from dead animals within the pens and during tagging operations. All marrows from femurs collected at the MRC were below 20% extracted fat. Number 23 female had been dead for some time before her femur was collected, but R70-5 female, 23 female and (25)69 calf were all found within 24 hours of death, so specimens were relatively fresh. Outside specimens varied in fat content (27-75%) but were uniformly higher in this respect than MRC specimens.

Such data suggest abnormally low nutrition within the enclosures. Several facts indicate that nutritional status "outside" may be equally poor. First, animals R70-5 and BK had not been enclosed, but were trapped outside the pens, so their 10% and 17% values reflect the same population as the specimen from PA-54.

Finally, mortality within the pens is not demonstrably different from that outside. This is shown by Table 5, which incorporates aerial counts, and by carcass collections made in June 1970 of un-handled animals in the Moose River Flats (GMU 15A) outside the MRC. In 3 hours of flying, 6 calf and 7 adult female carcasses were located (in addition to 5 hunter-killed males). The area searched was larger than the MRC's 4 square miles, but it was searched superficially by comparison.

Serological and hematological values for moose: Tables 8-15 and Figs. 3-18 itemize and summarize serological and hematological data gathered for moose during the reporting period. The data show seasonal differences for many parameters, as well as age, sex and reproductive status related differences. Seasons are designated as follows: spring - May and June; summer - July and August; rut - September and October; early winter - November through February; late winter - March and April. Essentially, the present values will serve as baselines for comparison of future values. Pathological and extreme nutritional difficulties in future specimens should be evident immediately, and when general condition parameters (ie: weight) are known for more serially-bled animals, more subtle indicators should emerge. From these baseline data, it is obvious that many constituents are condition-related (eg: Ca, P, Glucose and others are depressed during late winter; Uric Acid, total protein, and bilirubin are elevated during pregnancy, etc.). Some (BUN, glucose and others) are probably more sensitive to changes in condition than others. It remains to collect further specimens from populations we know are stressed, and to establish whether significant differences can be found in the levels of these constituents.

A brief discussion of factors that may alter each parameter, including comparison with previous work and theoretical aspects, follows. Cole (1967) and Davidsohn and Henry (1969) are the primary sources of information in the following discussions.

Table 6: Mortalities within pens June 1968 - June 1970.

Moose #	Sex	Age	Pen#	Month	Cause
4	F	17+	1	April	Winter - old age: carcass found
12	F	8+	2	May-July	Unknown: carcass found
13	F	Ad	2	June-January	Unknown: disappeared
3995	F	7	2	July	Unknown: carcass found
15	M	3+	2	Post-October	Unknown: disappeared
23	F	Ad	4	October-April	Unknown: had aborted, no fat, carcass found
25	F	Ad	4	February-May	Unknown: carcass found
29	F	Ad	4	October-January	Unknown: carcass found, not pregnant
44	M	Ad	4	October-January	Unknown: disappeared
14	F	Ad	2	August	Trapped in hole
R70-5	F	Ad	Outside: put in pen 2	May	Calving complications; carcass found
5050	F	Ad	3	October	Killed with drug
26	F	Ad	3	May	Killed with drug; pregnant 600 lbs.
368	?	Calf	1	June-October	Unknown: disappeared
168	?	Calf	1-2	September-October	Unknown: disappeared
769	?	Calf	2	January	Unknown: carcass found
969	M	Calf	2	June	Deserted after tagging
969	F	Calf	2	June	Deserted after tagging
1269	?	Calf	2	July	Mother died July
(25)69	M	Calf	4	1 February	Pneumonia: wt. 160 lbs.
2969	?	Calf	4	October-January	Mother died (see above)
GM69	?	Calf	4	March-April	Unknown: carcass found

Table 7. Femur-marrow and weight data.

Moose #	Sex	Age	Location	Month	Weight (lbs.)	% Extracted Fat (femur)	Condition
R70-5	F	Ad	Outside	May		9.65	2 fetuses; 1 breech
23	F	Ad	Pen 4	October-April		0.16	Found dead, not pregnant
26	F	Ad	Pen 3	May	600	0.14	Killed, one fetus
DOA2	F	5+	15A	March		26.96	Killed, not pregnant
DOA1	F	2+	15A	March		62.37	Killed, not pregnant
PA54	F	Ad	15A	June		44.68	Killed
SK	F	Ad	15A	April		74.73	Found dead; 2 fetuses
BK	F	12+	Outside	May		16.70	Killed, not pregnant
(25)69	M	Calf	Pen 4	1 Feb.	160	0.26	Died of pneumonia

Table 8. Mean serological values of moose June 1969 through May 1970. (* indicates male-female difference is significant at $P < .05$)

	Males			Females		
	(n)	Mean	s	(n)	Mean	s
Calcium (mg %)	(30)	10.84	1.53	(160)	10.06	1.12
Inorganic Phosphorous (mg %)	(30)	6.20	1.70	(160)	5.78	2.01
Glucose (mg %)	(30)	105.33	58.74	(157)	122.00	66.08
BUN (mg %)	(30)	5.81*	5.27	(158)	10.57*	12.23
Uric Acid (mg %)	(30)	4.06	17.82	(158)	1.26	6.31
Cholesterol (mg %)	(30)	72.02*	17.37	(160)	85.41*	23.10
Total Protein (gm %)	(30)	5.92*	1.46	(160)	6.59*	1.19
Albumin (gm %)	(29)	1.34	1.64	(158)	1.11	0.93
Bilirubin (mg %)	(30)	0.39	0.20	(160)	0.43	0.23
Alkaline Phosphatase(mU/ml)	(30)	75.84	85.51	(160)	69.33	65.06
LDH (mU/ml)	(30)	424.50	122.47	(160)	391.75	132.47
SGOT (mU/ml)	(30)	194.33	48.62	(160)	191.96	201.41

Table 9. Age-related differences in serological values for moose.
(175 adults, 9 yearlings, 5 calves)

	Adults		Yearlings		Calves		P_1 (Ad vs yrlgs.)	P_2 (Ad vs calves)
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.		
Calcium (mg%)	11.04	1.28	10.62	1.28	10.70	0.88	.01	.01
Inor. Phosphouous (mg%)	5.80	2.02	7.47	1.68	6.36	1.15	.001	.001
Glucose (mg%)	115.23	53.44	165.55	161.85	127.00	29.77	NS	.001
BUN (mg%)	9.81	10.05	5.56	3.13	4.54	2.43	NS	NS
Uric Acid (mg%)	0.70	0.33	0.74	0.27	0.82	0.16	NS	NS
Cholesterol (mg%)	85.74	21.61	70.53	14.23	73.00	9.80	.001	.001
Total Protein (gm%)	6.66	1.04	5.51	0.64	5.78	0.86	.001	.001
Albumin (gm%)			Not determined					
Bilirubin (mg)	0.45	0.41	0.32	0.08	0.26	0.08	.001	.001
Alk. Phosphatase (mU/ml)	67.90	70.34	84.44	53.67	109.00	42.24	.005	.005
LDH (mU/ml)	388.68	134.14	478.00	107.26	456.11	111.12	.001	.001
SGOT (mU/ml)	179.65	56.70	218.33	40.68	216.00	29.56	.001	.001

Table 10. Pregnancy - related differences in mean serological values for moose (3 pregnant, 11 non-pregnant)

	Pregnant		Non-pregnant		P
	$\bar{x}$	s	$\bar{x}$	s	
Calcium (mg%)	10.63	0.94	10.60	0.87	NS
Inorg. Phosphorous (mg%)	6.40	2.90	6.58	1.40	NS
Glucose (mg%)	50.00	36.29	122.27	55.94	.05
BUN (mg%)	48.33	33.62	12.73	9.97	NS
Uric Acid (mg%)	1.07	0.88	0.76	0.24	.001
Cholesterol (mg%)	98.33	24.61	78.63	7.71	NS
Total Protein (gm%)	7.43	0.17	6.05	0.47	.001
Albumin (gm%)	7.00	0.29	8.10	0.19	NS
Bilirubin (mg%)	0.87	0.66	0.45	0.17	.001
Alk. Phosphatase (mU/ml)	115.00	134.35	73.5	46.80	.025
LDH (mU/ml)	465.00	135.34	418.64	127.99	NS
SGOT (mU/ml)	206.67	36.82	195.45	60.99	NS

Table 11. Mean hematological values of moose June 1969 through May 1970. (Male - female differences insignificant in all cases)

	Males			Females		
	n	mean	s	n	mean	s
Hemoglobin (gm%)	21	14.04	5.06	67	14.43	6.22
Hematocrit (vol%)	21	37.95	13.77	66	37.51	13.19
WBC (/cc)	21	3057	1283	66	3563	1767
Eosinophils	16	4.94	4.56	67	5.70	4.27
Segmenters	22	28.14	18.67	91	27.65	17.01
Lymphocytes	23	66.74	20.35	92	68.76	17.27

Table 12. Age - related differences in hematological values for moose.

	Adults			Yearlings			Calves			P_1 (Ad vs yrlgs.)	P_2 (Ad vs calves)
	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s		
Hemoglobin (gm%)	88	14.34	6.02	1	16.4		1	9.2		No data	
Hematacrit (vol%)	65	37.68	13.16	No data			2	19.0	5.00	--	.001
WBC (/cc)	84	3463.1	1680.1	1	4800		2	1825	479.9	--	.005
Eosinophils	77	5.61	4.42	3	4.00	2.16	No data			.001	--
Segmenters	106	27.88	17.67	4	28.00	7.45	3	23.00		NS	NS
Lymphocytes	109	68.28	18.21	3	68.67	8.38	3	74.00	15.77	NS	NS

Table 13. Pregnancy-related differences in hematological values for moose.

	Pregnant			Non Pregnant			P
	n	$\bar{x}$	s	n	$\bar{x}$	s	
Hemoglobin (gm%)	17	9.96	4.92	3	13.83	1.43	.03
Hematocrit (vol%)	16	24.13	13.11	3	37.33	6.13	.03
WBC	16	2449	1538	3	1517	366	.07
Eosinophils	39	6.29	4.23	5	4.20	1.33	.05
Segmenters	47	19.30	11.84	5	23.80	13.27	NS
Lymphocytes	46	75.20	13.85	5	71.20	12.16	NS

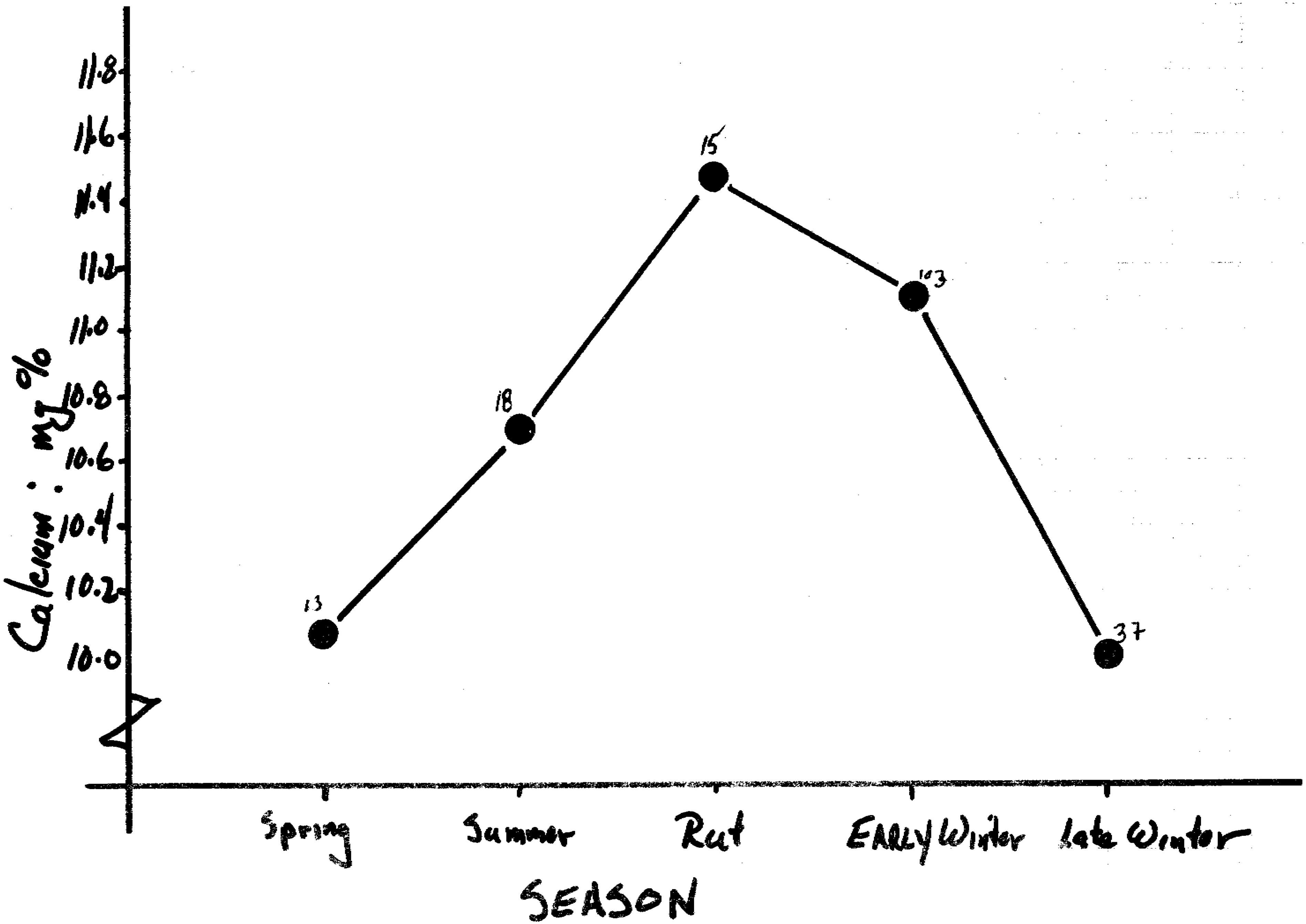
Table 14. Summary of significant (P $\leq$.05) changes in moose blood values with sex, age, and preganncy. Baseline is female, adult, not pregnant.
+ is an elevation, - a depression, 0 no significant change, nd no data

	Male	Yearling	Calf	Pregnant
Calcium	0	-	-	0
Inorg. Phosphorus	0	+	+	0
Glucose	0	0	+	-
BUN	-	0	0	0
Uric Acid	0	0	0	+
Cholesterol	-	-	-	0
Total Protein	-	-	-	+
Albumin	0	0	0	0
Bilirubin	0	-	-	+
Alk. Phosphatase	0	+	+	-
LDH	0	+	+	0
SGOT	0	+	+	0
Hemoglobin	0	nd	0	-
Hematocrit	0	nd	-	-
WBC	0	nd	-	-
Eosinophils	0	-	0	-
Segmenters	0	0	0	0
Lymphocytes	0	0	0	0

Table 15. Summary of significant (P - .05) changes in moose blood constituents with season. Each season is compared with the one immediately preceding it (eg: inorganic phosphorus is significantly higher in spring than in late winter.
(+ is an elevation, - a depression, 0 no significant change, nd no data)

	Spring	Summer	Rut	Early Winter	Late Winter
Calcium	0	+	+	-	-
Inorganic Phosphorus	+	-	0	+	-
Glucose	0	+	0	-	-
BUN	+	0	-	-	-
Uric Acid	0	+	-	+	0
Cholesterol	-	+	-	-	+
Total Protein	-	+	0	-	+
Albumin	0	0	0	0	0
Bilirubin	+	0	0	-	0
Alk. Phosphatase	+	_	0	+	-
LDH	+	+	-	0	-
SGOT	+	0	0	+	-
Hemoglobin	-(May & June)		+	-(Nov.-Feb.)	
Hematocrit	-	+	+	-(Winter)	
WBC	-	0	0	0	
Eosinophils	nd	-	0	0	
Segmenters	+	0	-	-	
Lymphocytes	-	nd	0	+	

Figure 3



Calcium : mg %
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0
15
18
103
13
37
Spring
Summer
Rut
EARLY Winter
late Winter
SEASON

Figure 4.

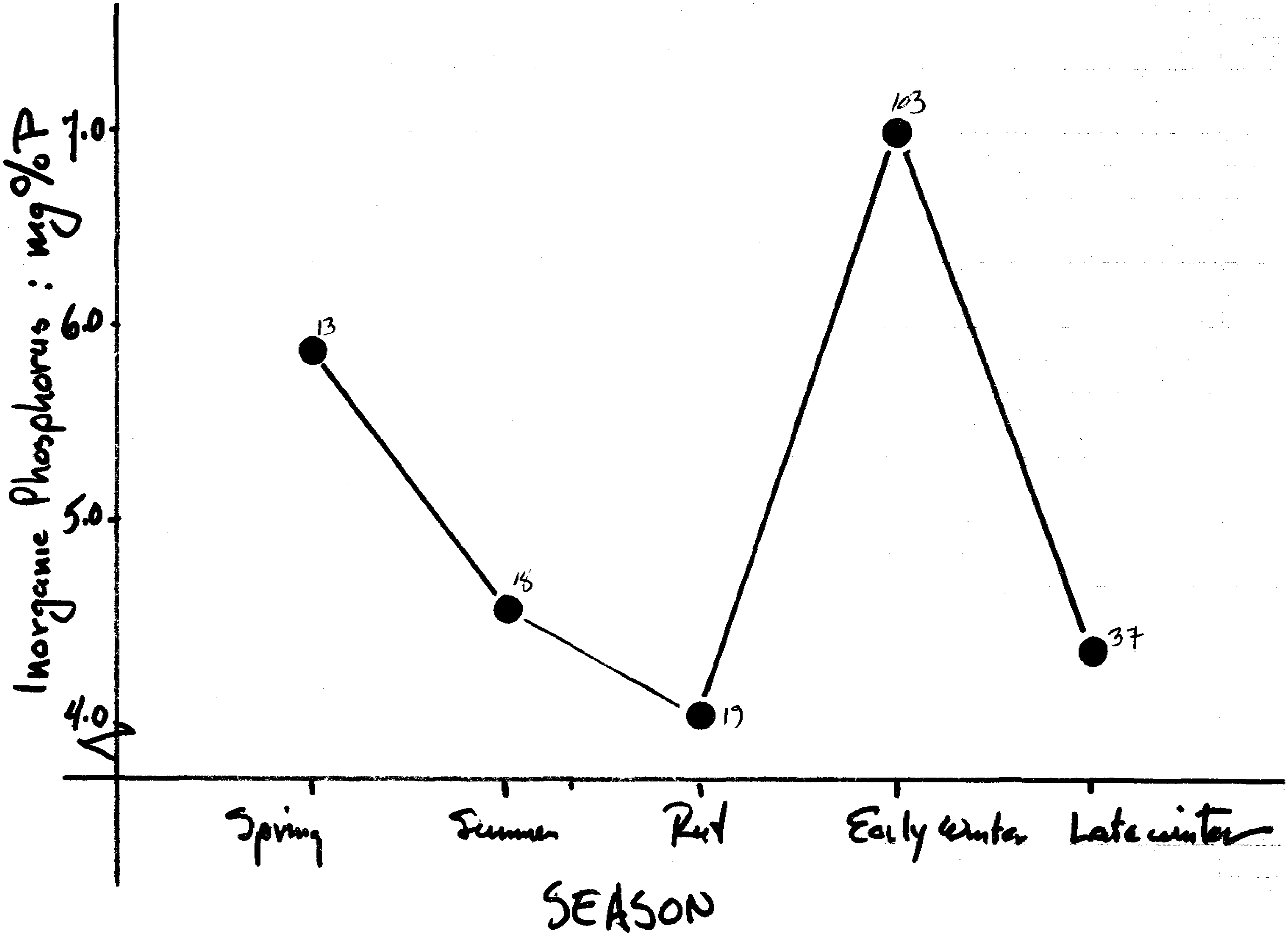

Inorganic Phosphorus : mg% P
7.0
6.0
5.0
4.0
103
13
18
19
37
Spring
Summer
Rut
Early Winter
Late winter
SEASON

Figure 5.

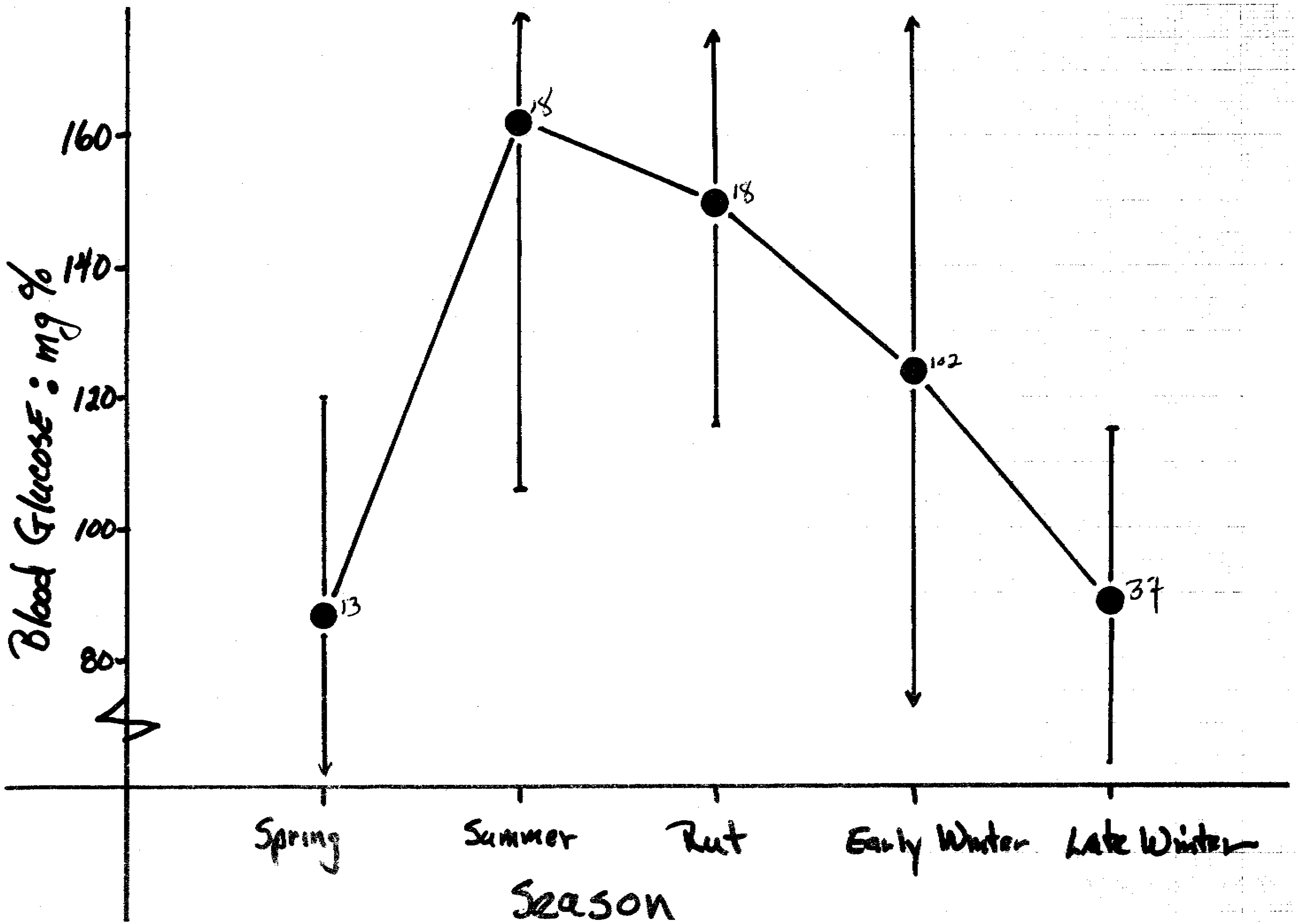

Blood Glucose: mg %
160
140
120
100
80
13
18
18
102
37
Spring
Summer
Rut
Early Winter
Late Winter
Season

Figure 6.

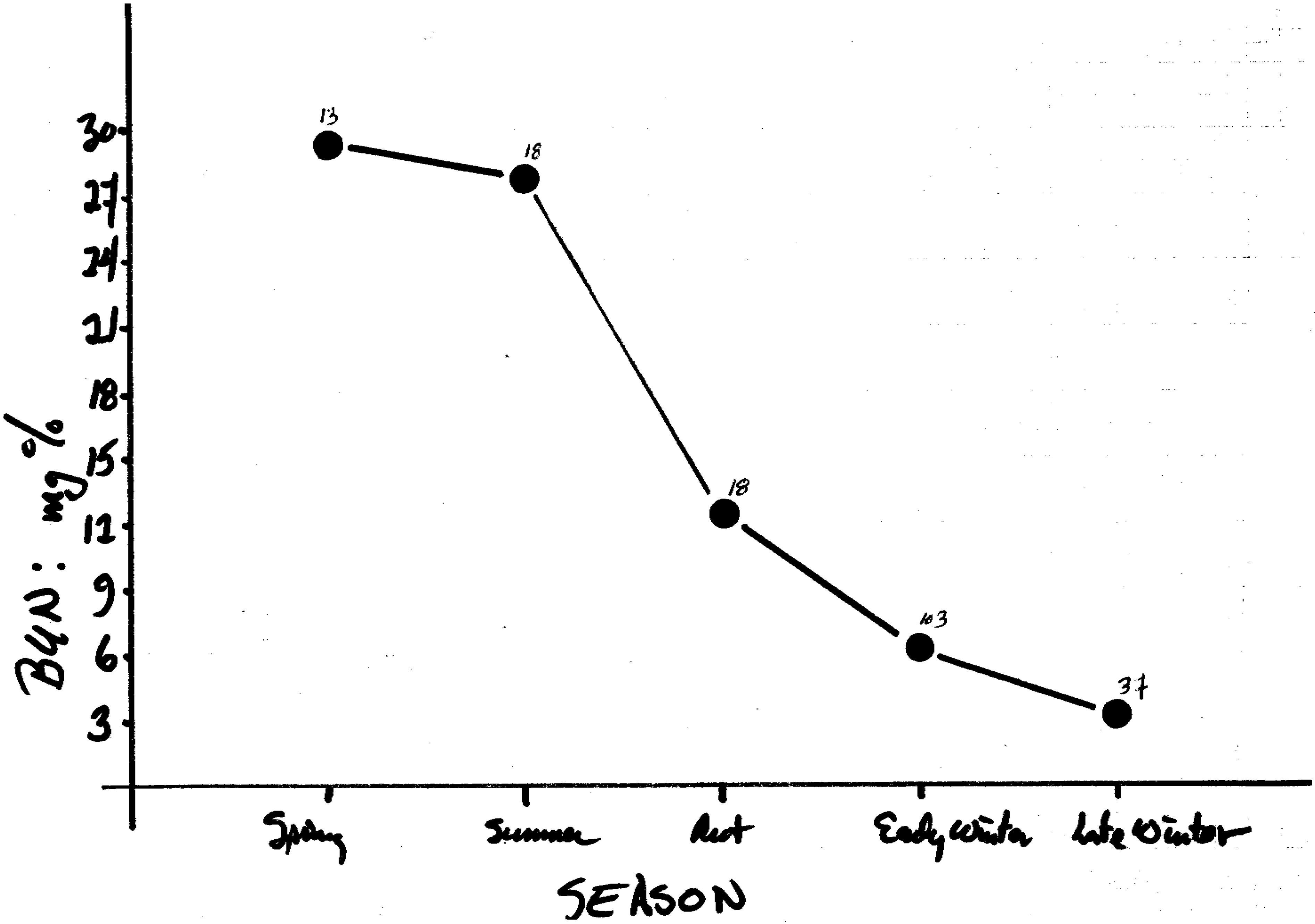
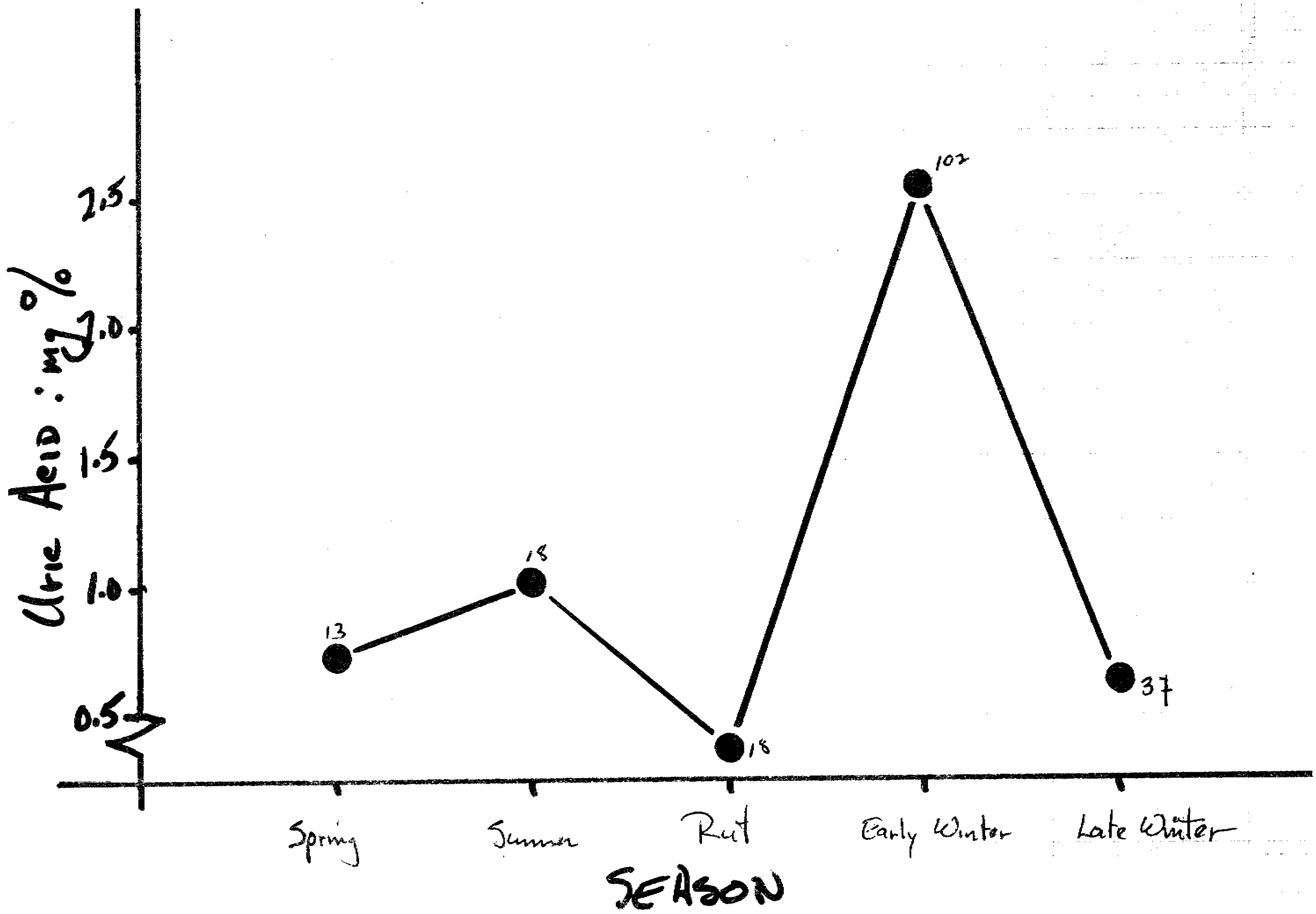
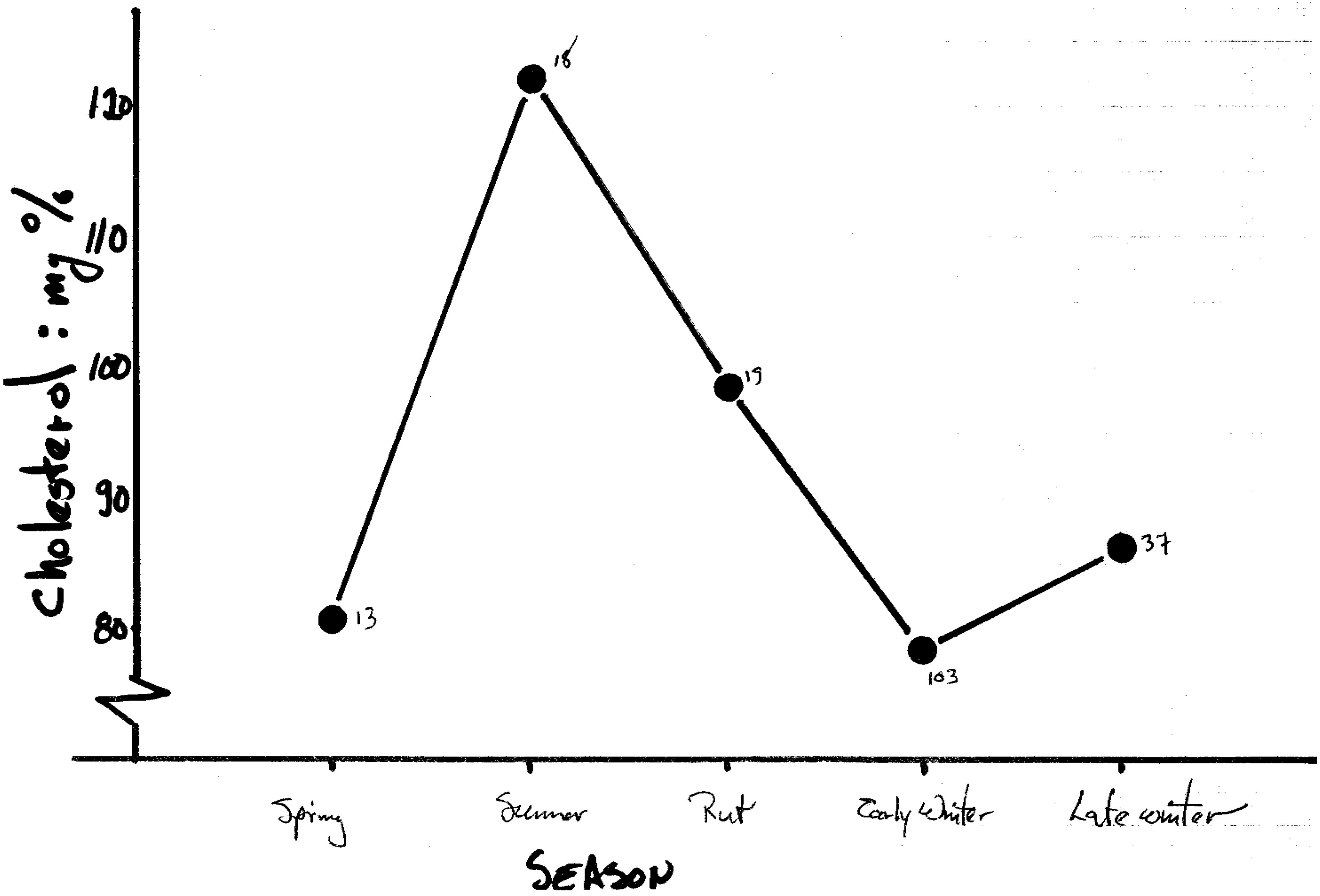

BUN: mg%
30
27
24
21
18
15
12
9
6
3
13
18
18
103
37
Spring
Summer
Early Winter
Late Winter
SEASON

Figure 7.



Uric Acid : mg %
2.5
2.0
1.5
1.0
0.5
102
18
13
18
37
Spring
Summer
Rut
Early Winter
Late Winter
SEASON

Figure 8.



Cholesterol : mg %
120
110
100
90
80
18
19
13
103
37
Spring
Summer
Rut
Early Winter
Late winter
SEASON

Figure 9.

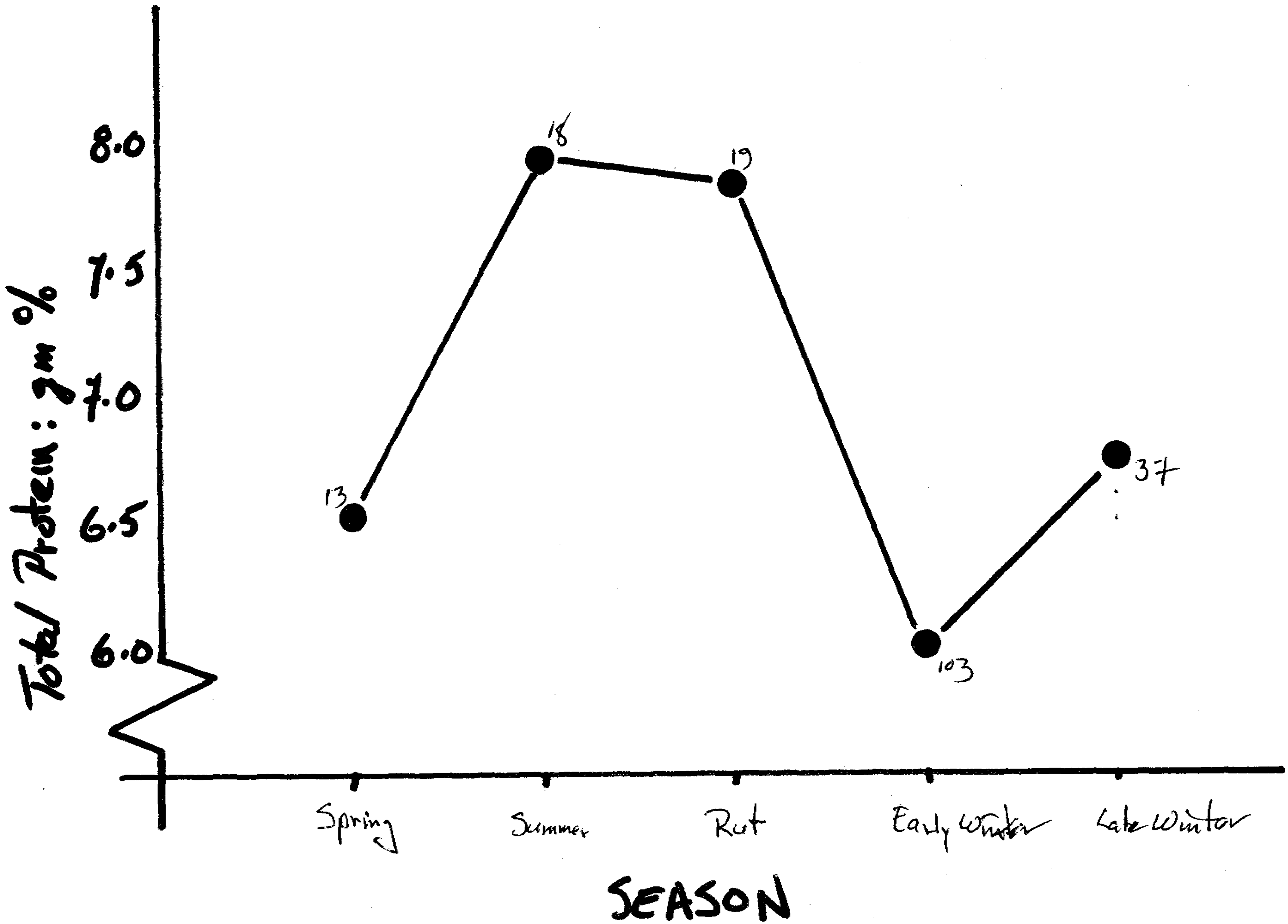
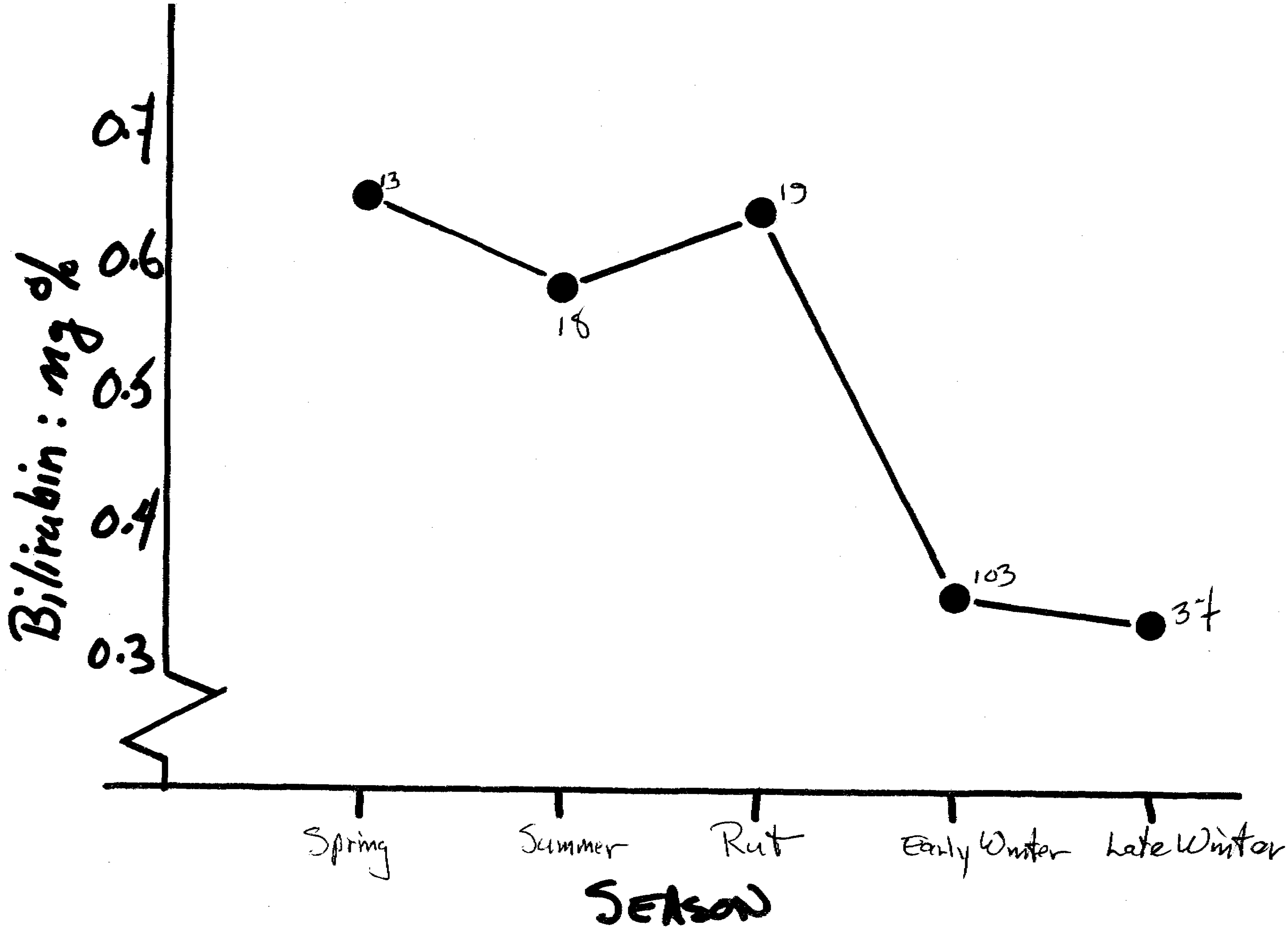

Total Protein: gm %
8.0
7.5
7.0
6.5
6.0
18
19
13
37
103
Spring
Summer
Rut
Early Winter
Late Winter
SEASON

Figure 10.



Billirubin : mg %
0.7
0.6
0.5
0.4
0.3
13
18
19
103
37
Spring
Summer
Rut
Early Winter
Late Winter
SEASON

Figure 11.

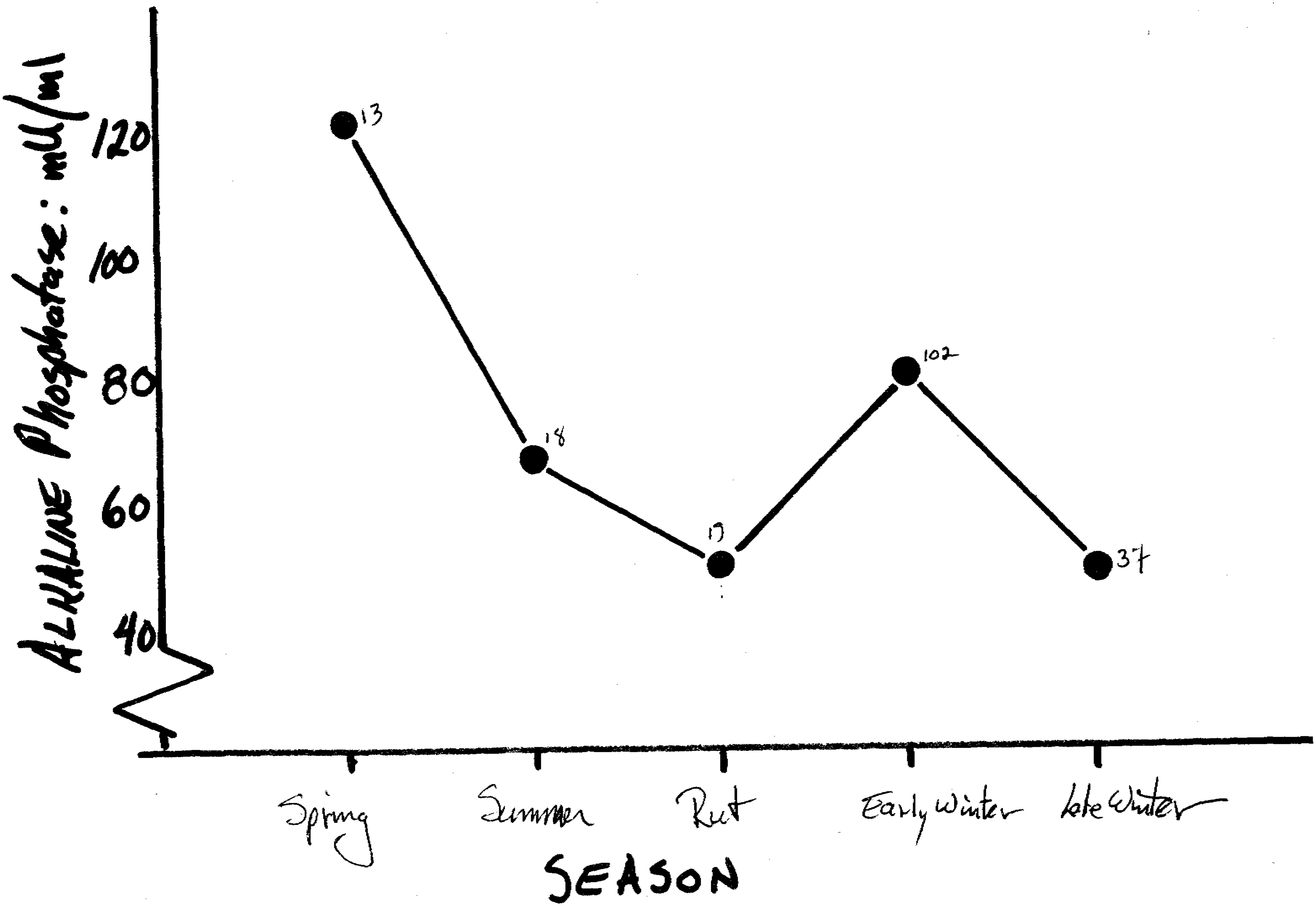
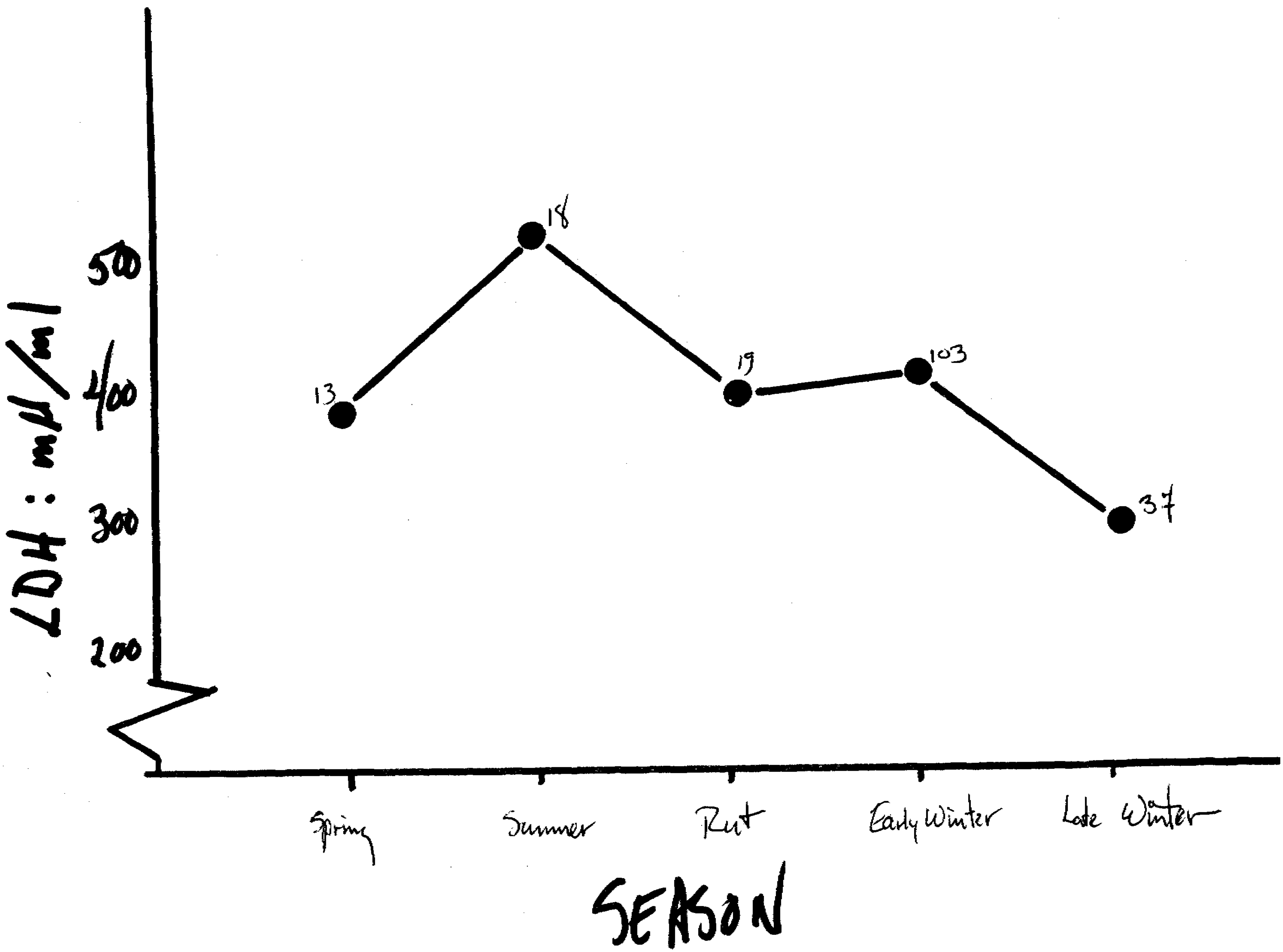

Alkaline Phosphatase: mU/ml
120
100
80
60
40
13
18
19
102
37
Spring
Summer
Rut
Early Winter
Late Winter
SEASON

Figure 12.



LDH : mU/ml
500
400
300
200
18
13
19
103
37
Spring
Summer
Rut
Early Winter
Late Winter
SEASON

Figure 13.

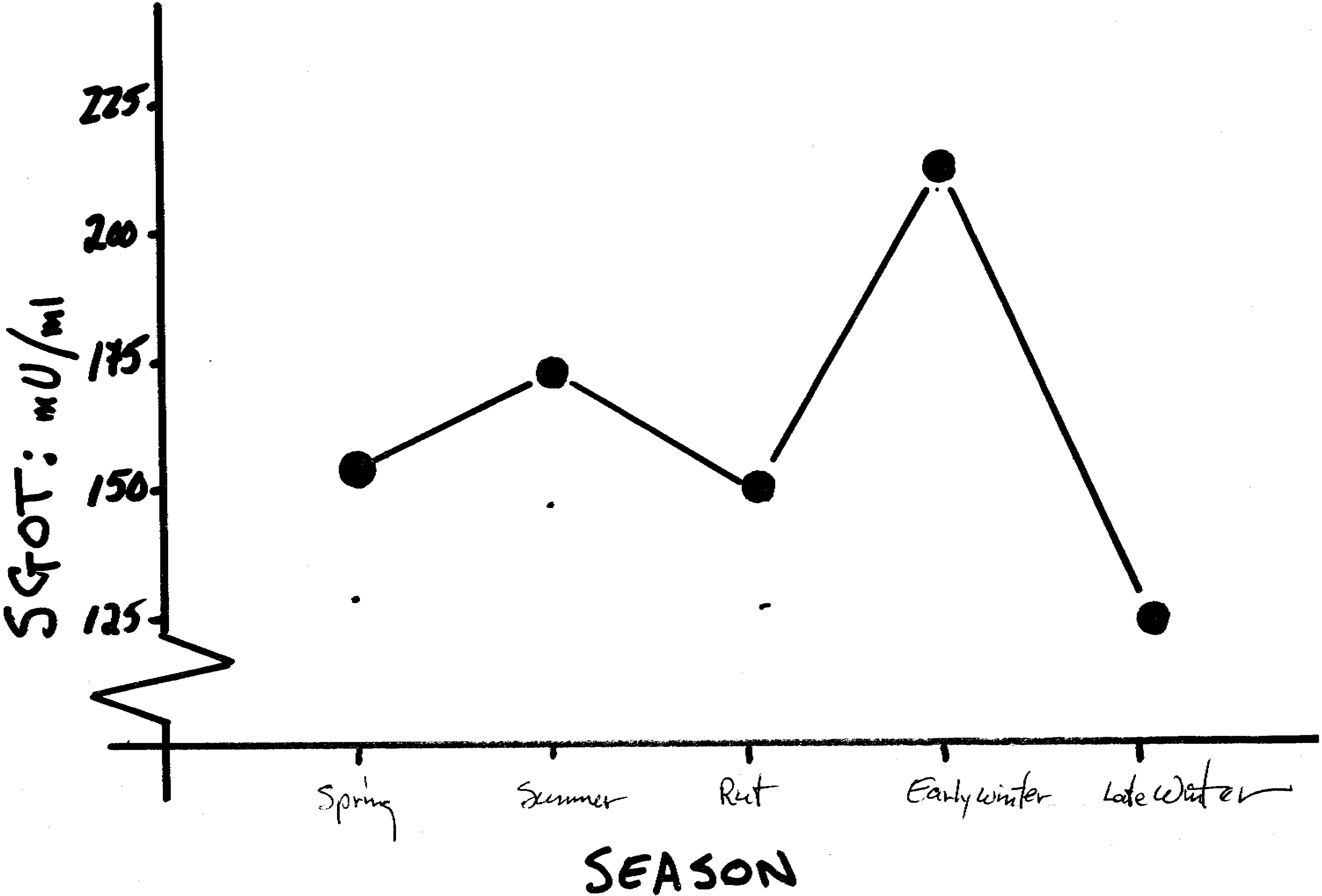

SGOT; mU/ml
225
200
175
150
125
Spring
Summer
Rut
Early winter
Late Winter
SEASON

Figure 14.

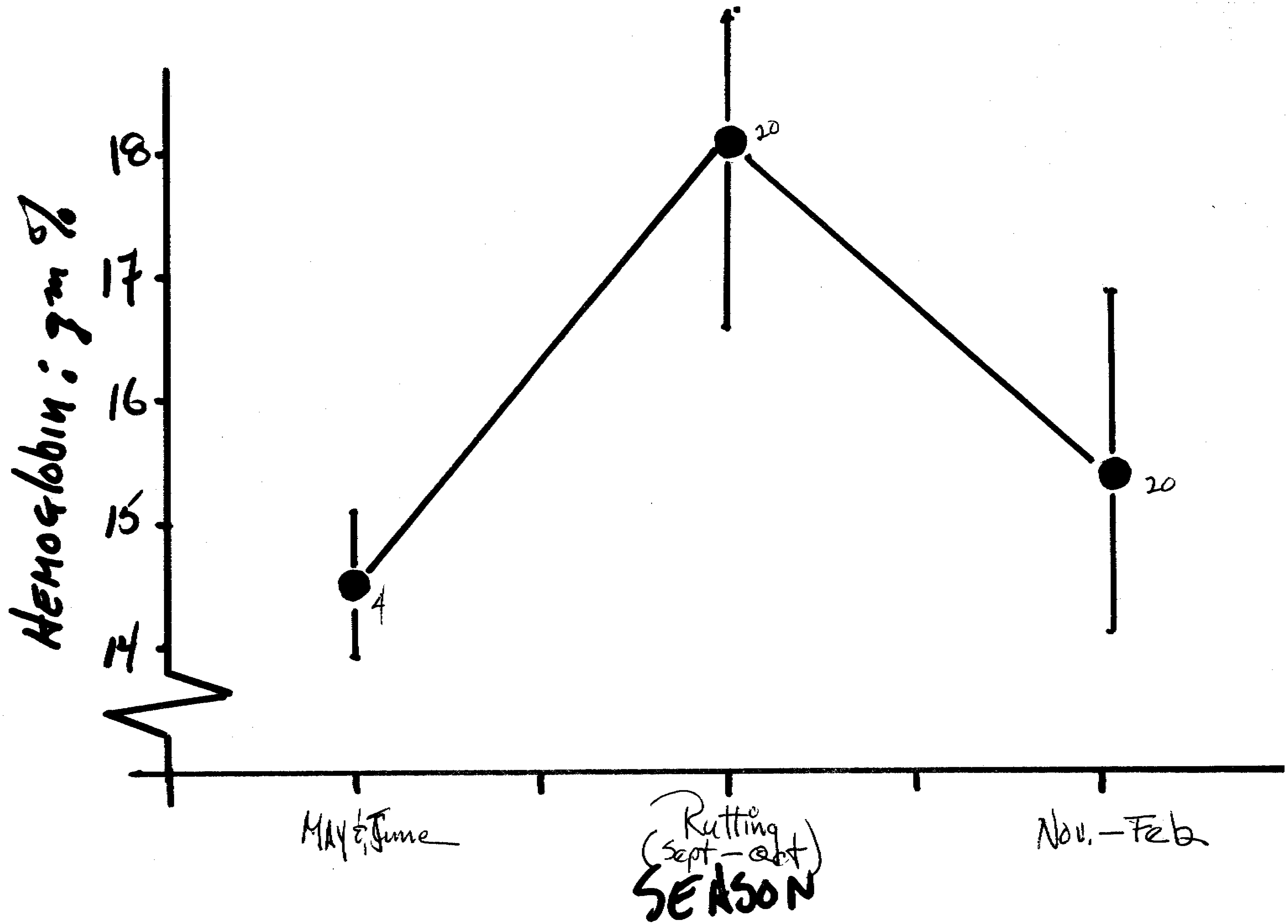

Hemoglobin: gm %
18
17
16
15
14
20
4
20
May & June
Rutting
(Sept–Oct)
Nov.–Feb
SEASON

Figure 15.

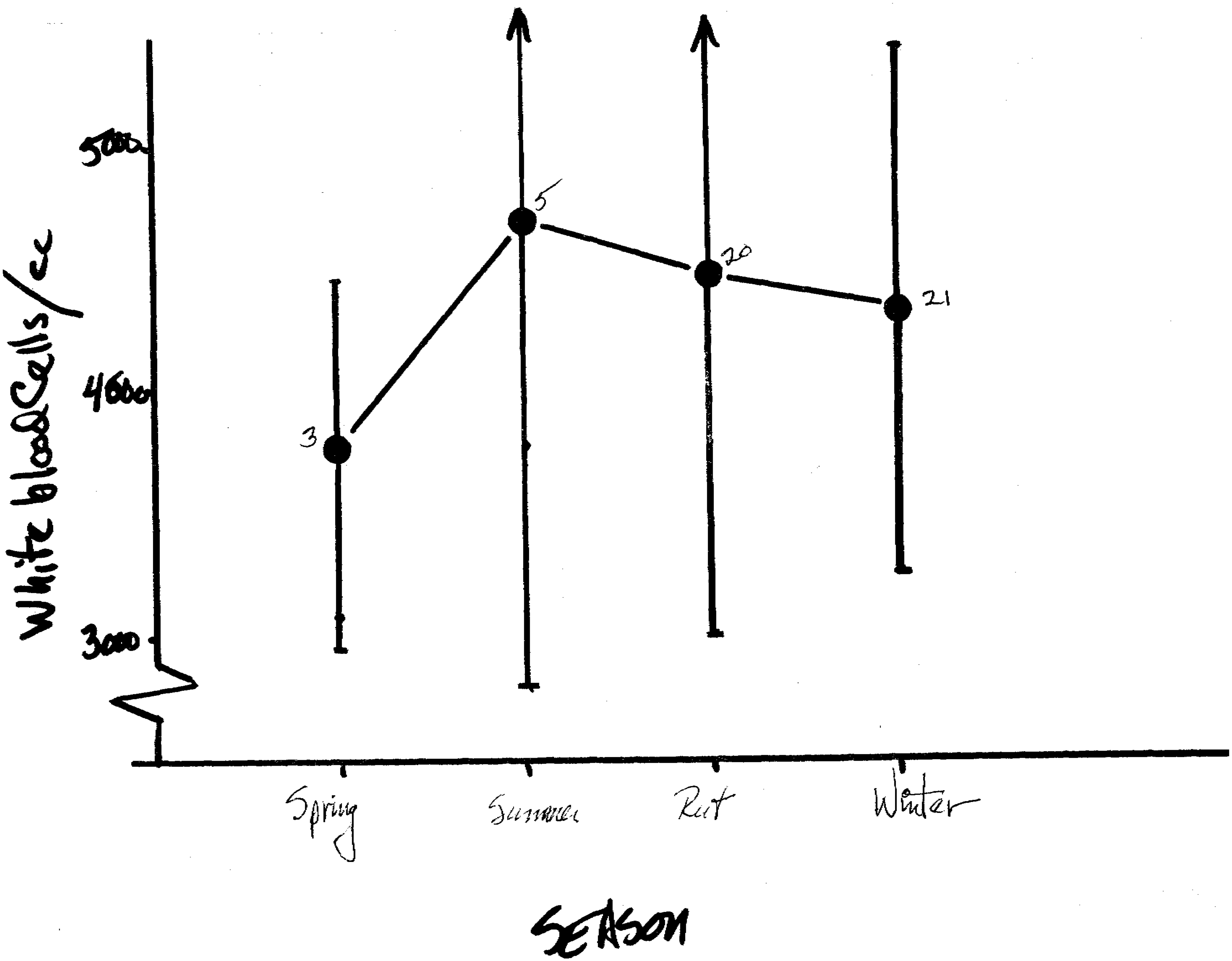

White bloodCells/cc
5000
4000
3000
3
5
20
21
Spring
Summer
Rut
Winter
SEASON

Figure 16.

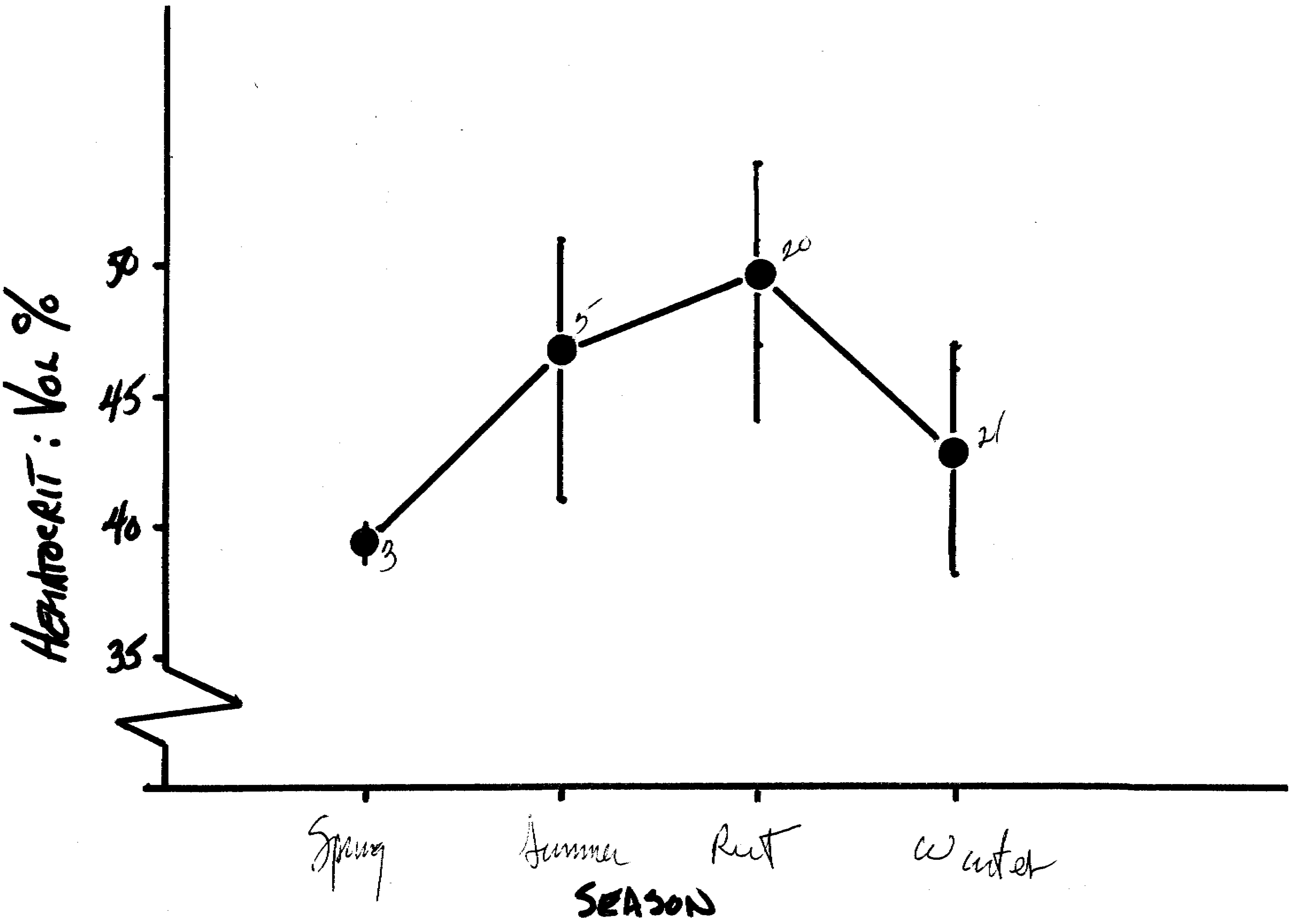

HEMATOCRIT : VOL %
50
45
40
35
3
5
20
21
Spring
Summer
Rut
Winter
SEASON

Figure 17.

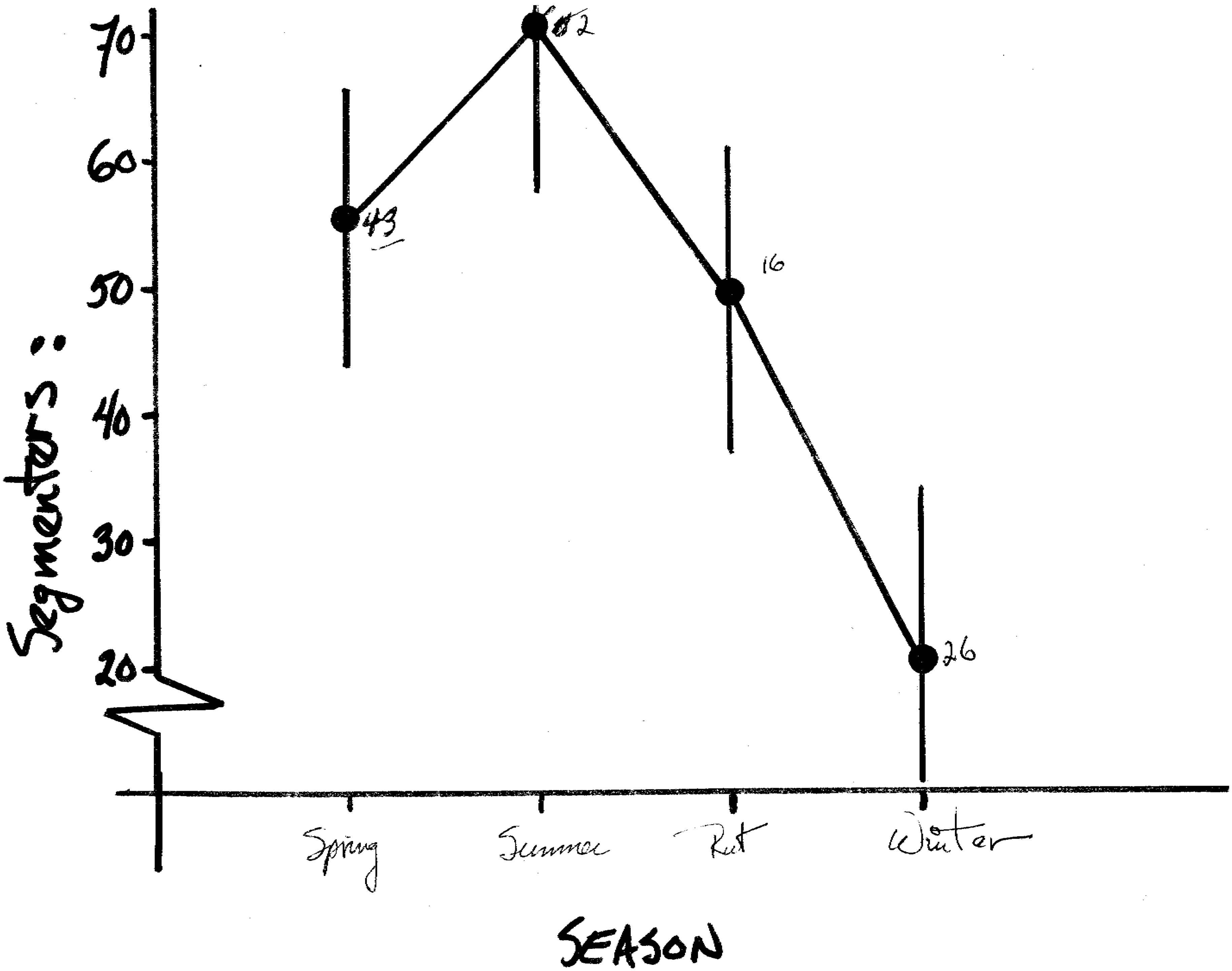
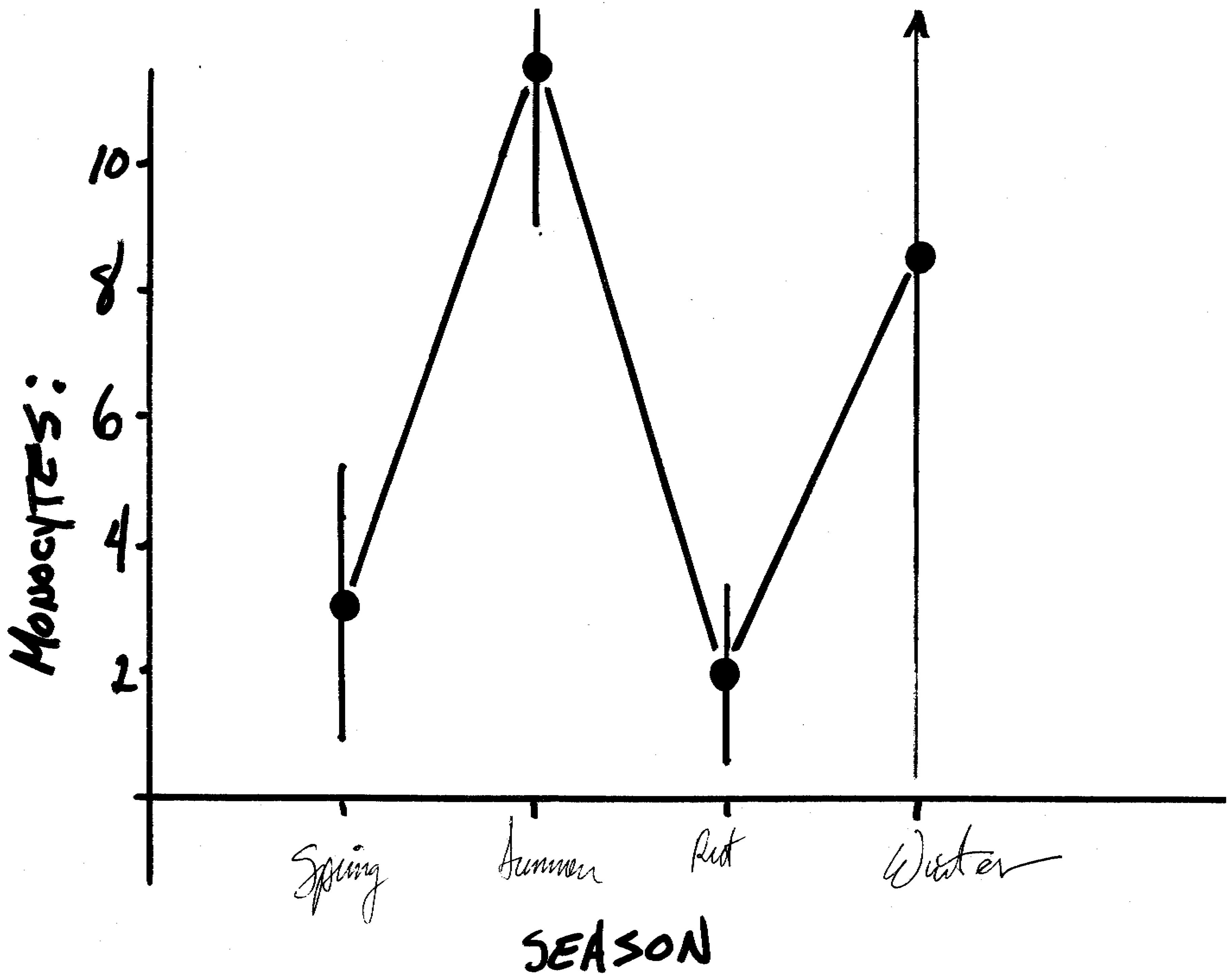

Segmenters :
70
60
50
40
30
20
43
16
26
Spring
Summer
Rut
Winter
SEASON

Figure 18.



1. Calcium: $\bar{x}$ = 11.04 mg% ± 1.28 S.D. for 175 adults
sexual variation: none
age variation: significantly lower in yearlings (10.62) and calves (10.70)
pregnancy variation: none
seasonal variation: rises spring through October; depressed thereafter

Discussion: Increase in calcium level may be due to hyperproteinemia, hyperparathyroidism, extreme neoplasia and other causes. Decreased calcium may result from hypoparathyroidism, vitamin D deficiency, acute or chronic renal failure, starvation associated with hypoproteinemia, parturient paresis (milk fever) and other causes. Thus, calcium depression during winter months may be related to reduced nutrition and possible hypoproteinemia and decreased vitamin D during this period. Similarly, depressed Ca may be indicative of range deterioration in certain instances.

2. Inorganic Phosphorous: $\bar{x}$ = 5.80 mg% ± 2.02 S.D. for 175 adults
sexual variation: none
age variation: significantly higher in yearlings (7.47) and calves (6.36)
pregnancy variation: none
seasonal variation: elevated following rut and following winter; depressed summer, rut and late winter

Discussion: Similarly to Ca, phosphorous is elevated in hypoparathyroidism, renal failure, and excessive vitamin D. Decreased inorganic phosphorus often results from simple lack of phosphorus intake, when lameness and swelling of the hocks often occurs. (cf: F 16, Pen 2, 3 August 1969 - table 3).

3. Glucose: $\bar{x}$ = 115.23 mg% ± 53.44 S.D. in 171 adults
sexual variation: none
age variation: significantly higher (127.00) in calves
pregnancy variation: significantly lower (50.0 vs 122.3) in pregnant females
seasonal variation: elevated in summer; progressivly decreases through late winter

Discussion: Blood glucose is rapidly elevated during stress, so it is likely that the present mean values are greater than those found in calm animals. Reported Bovine and Ovine values vary from 35-74 mg% (Cole 1967). However, given that all samples from wild moose will be obtained under stress, comparison of values is possible.

Alterations in glucose level may be associated with pancreatic abnormalities (diabetes or insulin poisoning). Hypoglycemia may be an indication of starvation, although gluconeogenesis can maintain blood glucose at high enough levels to sustain life even in severe starvation if it persists only a short while. For this reason, uric acid (a product of protein catabolism in gluconeogenesis) is a more sensitive indicator. Ketosis may be accompanied by hypoglycemia, resulting from assorted digestive or nutritional disorders.

Houston (1969) reported a mean value of 62.7 ± 5.65 S.D. for 13 Shiras moose of assorted ages and sexes.

4. <u>BUN</u>: $\bar{x}$ = 9.81 mg% ± 10.05 S.D. in 173 adults
<u>sexual variation</u>: significantly lower (5.81 <u>vs</u> 10.57) in adult males
<u>age variation</u>: none
<u>pregnancy variation</u>: none
<u>seasonal variation</u>: highest in spring; depressed progressively through late winter.

<u>Discussion</u>: BUN results from protein catabolism, and its elevation may be due to excessive protein breakdown or, more usually, to renal failure. In addition, however, an increase in dietary protein may increase BUN.

Depressed BUN levels are uncommon, but most usually result from decreased protein intake or absorption.

Houston (1969) reported BUN values of 12.9 ± 3.0 during July-September (n=7) and 5.1 ± 1.8 during October-February (n=5). He speculated that BUN levels reflected changes in nitrogen balance due to nutritional changes. That the present values are highest in spring and summer supports this thinking.

5. <u>Uric Acid</u>: $\bar{x}$ = 0.702 mg% + 0.332 S.D. for 172 adults
<u>sexual variation</u>: none
<u>age variation</u>: none
<u>pregnancy variation</u>: significantly higher (1.07 <u>vs</u> 0.76 in pregnant cows.
<u>seasonal variation</u>: elevated in early winter, after rut

<u>Discussion</u>: Uric acid is a product of amino acid breakdown, and as such, is increased in starvation for three reasons: 1) increased tissue (ie: protein) turnover, 2) decreased renal excretion of the chemical due to acidosis, and 3) gluconeogenesis, with uric acid as a waste product.

The obvious elevation of serum uric acid following rut possibly results from decreased food intake during this period, but the winter period of low nutrition is not sufficient (at least, not during 1969-70) to cause elevation.

Uric acid may also be markedly increased in hepatic disorders.

6. <u>Cholesterol</u>: $\bar{x}$ = 85.74 mg% + 21.61 for 175 adults
<u>sexual variation</u>: significantly lower (72.02 <u>vs</u> 85.41) in adult males
<u>age variation</u>: significantly lower in yearlings (70.53) and calves (73.00)

pregnancy variation: none

seasonal variation: highest in summer, decreasing progressively through early winter and spring, with a minor elevation in late winter.

Discussion: Cholesterol level is primarily of value as a reflection of diet and dietary changes (and of the state of rumen metabolism). It is elevated significantly when diets high in saturated fatty acids are being consumed. Consequently, starvation conditions may result in hypocholesterolemia. Pathological conditions that may alter cholesterol levels include thyroid and hepatic disorders and nephrosis. The observed seasonal variation in moose may reflect dietary changes in saturated fatty acids.

7. Total protein: $\bar{x}$ = 6.66 gm% + 1.04 for 175 adults

sexual variation: significantly lower (5.92 vs 6.59) in adult males

age variation: significantly lower in yearlings (5.51) and calves (5.78)

pregnancy variation: significantly higher (7.43 vs 6.05) in pregnant cows

seasonal variation: highest in summer and fall, depressed following rut and elevated through late winter and spring

Discussion: Total protein is a rather insensitive indicator of nutritional status, for it is maintained at near-normal levels except in extreme distress. In sub-clinical cases of undernutrition, albumin is a better indicator. Most commonly, hypoprotemia is the result of trauma (wounds, burns) or renal disease. Occasionally, however, it can result from gluconeogenesis and, as such, can reflect dietary insufficiencies. In cases of chronic protein starvation T.P. may decrease noticably.

Decreased total serum protein following rut may be a result of nutritional deprivation and tissue breakdown.

Houston (1969) reported a mean total protein of 6.38 ± 0.87 for 13 Shiras moose.

8. Albumin: $\bar{x}$ = 3.9 gm% ± 0.904 S.D. for 26 adults

sexual, age, pregnancy and seasonal variations: insufficient data at the present time.

Discussion: Albumin is the smallest of the serum proteins and forms 40-60% of the total protein. It is important as a source of amino acids and fatty acid transport, among other functions.

Depressed albumin may indicate, among other things, deficient protein intake or excessive protein breakdown. Decreased albumin is present in malnutrition and starvation. For these reasons, albumin determination may prove valuable in our studies. Present data (26 determinations) are insufficient to evaluate.

Houston (1969) reported albumin $\bar{x}$ = 4.47 ± 1.38 S.D. for his 13 Shiras moose.

9. Bilirubin: $\bar{x}$ = 0.45 mg% + 0.41 for 175 adults
sexual variation: none
age variation: significantly lower in yearlings (0.32) and calves (0.26)
pregnancy variation: significantly higher (0.87 vs 0.45 mg%) in pregnant cows
seasonal variation: depressed from early winter through late winter; re-elevated spring through fall

Discussion: Bilirubin is a pigment liberated in the RE system by breakdown of hemoglobin. Bilirubin measurement is commonly a test of liver function, for its elevation is symptomatic of hemolytic diseases. Other conditions elevating serum bilirubin include jaundice, cardiac insufficiency and gangrenous pneumonia. Coles (1967) suggests, however, that bilirubin is only slightly elevated in severe hepatic disease in bovines, ovines and caprines.

It seems unlikely bilirubin testing will prove valuable in assessing nutritional status of moose, although seasonal changes do suggest a limited dietary influence.

10. Alkaline Phosphatase: $\bar{x}$ = 67.90 mU/ml + 70.34 S.D. for 175 adults
sexual variation: none
age variation: significantly higher in yearlings (84.44) and calves (109.00)
pregnancy variation: significantly higher (115.0 vs 73.5) in pregnant cows
seasonal variation: elevated in spring and early winter

Discussion: Alkaline phosphatase hydrolyzes phosphoretic esters and is concentrated intracellularly in osteoblasts, renal tubules and the intestinal mucosa. In humans, changed concentrations of this enyzme are diagnostic for bone abnormalities and liver disease. Levels are normally elevated during periods of growth (cf: calves and yearlings) and during pregnancy, due to increased osteoblast activity and the enzyme's production in the placenta. Lowered levels can result from under-nourishment.

11. Lactic Dehydrogenase (LDH): $\bar{x}$ = 388.68 + 134.68 for 175 adults
sexual variation: none
age variation: significantly higher in yearlings (478.00) and calves (456.11)
pregnancy variation: none
seasonal variation: elevated in summer; depressed in late winter

Discussion: LDH catalyzes the lactic acid--pyruvic acid conversion, occurring in most tissues. In humans, elevated LDH levels are indicative of several pathological conditions (eg: pulmonary or myocardial infarction, hepatitis, cirrhosis, leukemia and carcinomas). No direct relationship to diet is evident, so the enzyme's usefulness in the present work is doubtful.

12. Glutamic oxalacetic transaminase (SGOT): $\bar{x}$ = 179.65 + 56.70 S.D. in 174 adults

sexual variation: none

age variation: significantly higher in yearlings (218.33) and calves (216.00)

pregnancy variation: none

seasonal variation: significantly elevated following rut (re: in early winter) and depressed in late winter

Discussion: SGOT is elevated in cases of necrosis involving the tissues rich in the enzyme. Its concentration is especially high in the heart, liver and skeletal muscle and thus elevation is a sensitive indicator of myocardial infarction, and hepatic and muscular necrosis. In cattle, SGOT elevation has been noted during starvation. That in the present sample of moose the enzyme is elevated in both sexes about 40% after rut through February suggests this measurement may prove of value in detecting stress conditions.

13. Hemoglobin: $\bar{x}$ = 14.34 gm% + 6.02 S.D. for 88 adults

sexual variance: none

pregnancy variance: significantly lower (9.9% vs 13.8%) in pregnant cows

seasonal variance: significantly elevated (18.1) during rut

Discussion: Measurement of hemoglobin is both of doubtful accuracy and of doubtful usefulness. Its level is indicative of oxygen-carrying capacity of the blood and its depression is indicative of various anemias. Its value, considered in light of other erythrocyte values (eg: hematocrit, PCV, MCV) can help delineate the type of anemia and give clues to its etiology.

Anemias may be hypochromic or normochromic; examples of hypochromic types being caused by various poisonings, bacterial diseases, parturient hemoglobinuria, parasitic infections, or dietary deficiencies of iron or copper. Hemoglobin determination thus may prove useful in some naturally-occuring situations in moose.

14. Hematocrit: $\bar{x}$ = 37.68 vol% + 13.16 S.D. for 65 adults

sexual variation: none

age variation: significantly lower (19.00) in 2 calves

pregnancy variation: significantly lower (24.13 vs 37.33) in pregnant cows

seasonal variation: lowest in spring; increases progressively through September-October and then falls during winter

Discussion: Hematocrit is used in conjunction with hemoglobin measurement as an indicator of the state of the erythocyte system. See discussion of use of hemoglobin values.

15. Leukocytes: (WBC) $\bar{x}$ = 3463 ± 1680 cells/cc for 84 adults
sexual variation: none
age variation: significantly lower (1825) in calves
pregnancy variation: significantly higher (2449 vs 1517) in 16 pregnant vs 3 non-pregnant females
seasonal variation: slightly depressed in spring

Discussion: WBC and differential counts are most useful in diagnosing various infections, intoxications, and neoplasms. Changes in absolute numbers and relative proportions of the several leukocytic cell types, when considered with other symptoms, can help differentiate between various disorders. However, individual variation makes serial bleeding of the same animal almost essential if small changes are to be detected. No direct nutritionally related changes in WBC or differential counts have been firmly established, but such information can prove of value in discovering pathology resulting from nutritional deprivation.

Browse utilization: Raw (twig-count and weight) condensed data for browse utilization during winters of 1968-69 and 1969-70 are given in Tables 16-19. Table 20 gives estimates of utilization in pounds/moose/day, given a browsing period of 210 days and calculating from the mean number of moose present during the period considered. The statistical unreliability of the data makes them of doubtful value, and necessitates redesigning the sampling procedure. This will be done in cooperation with USFWS, who have primary responsibility for vegetation analysis.

Extreme variation in sampling may result from more than only lack of sufficient sample size. It could be indicative of the very low percentage utilization of available browse. The only percent-utilization estimates are found in Bishop (1969), for Pens 1 and 2 during the winter of 1967-68. Seemel's data, reported there, showed less than 20% utilization of all species in Pens 1 and 2, and estimated production of greater than 720,000 pounds/square mile.

Mean twig wet weight estimated from clipping (Table 19) was 2.73 g in the winter of 1968-69, but only 1.05 g for 1969-70. This difference in the expansion factor (ie: parameter used to estimate pounds utilization given number of twigs browsed) accounts for 54% of the difference between utilization estimates for Pens 1 and 2 in spring 1969 and 1970. Two possible contributive factors are not obvious: first, twig-clipping was done by different individuals in the two years--Seemel in 1969 and Milke in 1970. Standard deviations are so great, however (cf: Table 19) that the worker doing the clipping may not be the greatest variable.

Second, the summer of 1969 was extraordinarily dry, with no measurable precipitation at the MRC in July or August. Annual growth could have been as much as 62% (ie: $\frac{2.73 - 1.05}{2.73}$) lower that summer. However, a compensatory increase in numbers of twigs browsed should have been evident were this the case.

Table 16. Numbers of birch (*B. papyrifera*) twigs browsed in 8 x 24 foot sample plots measured in April 1969. Kenai Moose Research Center.

	Habitat Type							
	Birch			Spruce-		Mature Hardwoods		
	Dense	Medium	Thin	Birch	Spruce	Dense	Thin	No. Moose
Pen 1								
n	25	26	25	24	20	20	20	
$\bar{x}$	39.60	28.85	33.88	23.88	3.35	2.55	11.60	7
s	38.68	22.52	33.16	20.29	8.06	5.67	14.25	
Pen 2								
n	30	31	30	24	30	25	25	
$\bar{x}$	90.43	54.45	57.27	55.33	7.07	3.32	7.00	14
s	59.53	50.88	52.48	42.58	15.55	6.73	12.14	

Table 17. Numbers of birch (B. *Papyrifera*) twigs browsed in 8 x 24 foot sample plots measured in April 1970. Kenai Moose Research Center.

	Birch			Spruce		Mature Hardwoods		
	Dense	Medium	Thin	Spruce-Birch	Spruce	Dense	Thin	No. Moose
Pen 1								
n	22	26	25	24	20	19	21	
$\bar{x}$	39.63	30.96	13.92	13.13	0	1.47	6.81	7
s	39.71	28.12	15.97	15.15	-	4.34	9.61	
Pen 2								
n	32	31	30	211	30	21	26	
$\bar{x}$	55.41	50.68	28.84	29.05	0.23	1.76	8.50	12
s	49.13	40.92	33.45	25.79	1.26	4.20	20.77	
Pen 3								
n	25	25	25	25	25	25	25	
$\bar{x}$	67.12	68.56	52.48	21.56	21.92	1.00	13.20	12
s	65.56	49.97	47.58	27.14	35.74	3.14	32.93	

Table 17. Numbers of birch (B. *Papyrifera*) twigs browsed in 8 x 24 foot sample plots measured in April 1970. Kenai Moose Research Center.

	Birch			Spruce		Mature Hardwoods		
	Dense	Medium	Thin	Spruce-Birch	Spruce	Dense	Thin	No. Moose
Pen 4								
n	23	27	19	24	26	24	31	
$\bar{x}$	103.39	123.29	103.06	67.88	25.69	3.75	24.19	16
s	64.45	72.24	65.96	50.33	25.49	13.16	35.01	
Calf Pen								
n	4	5	13	9	7			
$\bar{x}$	146.00	81.00	56.00	51.33	98.86			
s	30.33	57.68	18.43	39.94	72.83			

Table 18. Summary of numbers of birch (*B. papyrifera*) twigs browsed in 8 x 24 foot sample plots. Kenai Moose Research Center.

		Habitat Type			
		Birch	Spruce	Mature	$\bar{x}$
<u>Pen 1</u>					
1969:	n	76	44	40	160
	$\bar{x}$	34.04	14.77	7.05	21.99
	s	32.35	18.82	11.76	27.73
1970:	n	73	44	40	157
	$\bar{x}$	27.74	7.16	4.28	17.60
	s	30.92	12.96	8.03	28.77
<u>Pen 2</u>					
1969:	n	91	54	50	195
	$\bar{x}$	64.64	28.52	5.16	40.44
	s	53.95	40.41	4.98	51.69
1970:	n	94	51	47	192
	$\bar{x}$	45.09	12.12	5.49	26.63
	s	43.32	21.81	16.05	37.95
<u>Pen 3</u>					
1970:	n	75	50	50	175
	$\bar{x}$	64.08	21.75	7.10	35.70
	s	53.40	31.73	24.17	49.03
<u>Pen 4</u>					
1970:	n	69	50	55	174
	$\bar{x}$	111.09	45.94	15.28	61.61
	s	68.71	44.70	27.53	66.64

Table 19. Weights of twigs clipped in April 1970 for estimating pounds of browse utilized from twig count data (Table 17)

	n	$\bar{x}$(grams)	s
		Wet Weights	
Pen 1			
Thin-Birch Type	100	0.96	1.05
Dense-Birch Type	100	1.30	1.07
Total	200	1.14	1.08
Pen 4			
Thin-Birch Type	100	0.88	0.76
Dense-Birch Type	100	0.83	1.01
Total	200	0.85	0.89
		Dry Weights	
Pen 1			
Thin-Birch	99	0.62	0.65
Dense-Birch	100	0.72	0.62
Total	199	0.67	0.64
Pen 4			
Thin-Birch	99	0.53	0.43
Dense-Birch	100	0.52	0.60
Total	199	0.52	0.52

Table 20. Estimated browse utilization (pounds) in Kenai Moose Research Center enclosures. 1968-69 and 1969-70 winters

	1968-1969			1969-1970					
Species	Pen 1	Pen 2	Pen 1 + Pen 2	Pen 1	Pen 2	Pen 3	Pen 4	Pen 1 + Pen 2	All Pens
Birch	15,517	27,168	42,685	4,649	6,496	8,758	16,080	11,145	
Willow	1,184	887	2,071	323	421	838	791	744	
Aspen	330	1,037	1,367	67	61	222	446	128	
Cottonwood	27		27						
Viburnum	104	52	156				32		
Rose	136		136		5	29	144	5	
Dwarf Birch		3,584	3,584				26		
Alder		209	209			336			
Total	17,299	32,937	50,236	5,039	6,983	10,183	17,519	12,022	39,724
No. Moose	7	14	21	7	12	12	16	19	47
Lbs/moose/day	11.8	11.2	11.4	3.43	2.77	4.05	5.22	3.01	4.02
Estimated s	±26.6	±25.6	±26.0	±7.75	±6.73	±9.68	±10.83	±7.07	±9.20

The remaining 46% of the '69-'70 change may be due in great part to the enormous sampling variance (note that s values are near 100% of means). However, another weather factor may have operated. The 1969-70 winter was extremely mild, and green vegetation (eg: Vaccinum, Pyrola) was available almost throughout the year. This could have reduced the estimator of 210 days in which only browse is taken.

Some general subjective observations re: browse utilization are of interest:

1. The dominant browse species (birch, B. papyrifera) is seldom found in a hedged condition, despite the rather high ($\bar{x}$ = 11.8 moose/square mile) and probably stabilizing population of moose present year-round.

2. What little willow (Salix spp) and aspen (Populus tremuloides) is present is in severly hedged condition. Many plants of these species have been either killed or severly retarded in annual growth. Viburnum edule, rarer than the other two, seems similarly affected. Percent utilization data for these species for the past two years are not available, nor are results of successional plot readings.

RECOMMENDATIONS

1. Moose populations within the Kenai Moose Research Center enclosures are valid approximations of unenclosed moose populations in terms of natality, mortality, recruitment and general condition. Results of research concerning these population characteristics are therefore validly applied to other populations. It can be postulated that moose in Unit 15A are at maximum possible density and should therefore not be managed with increase in mind.

2. Blood serum analyses are of great potential in determining nutritional status and general health of moose, given valid baselines for various ages, sexes and seasons. In situations where poor nutrition, poor calf survival or poor natality are suspected, sera should be collected from as many animals as practical and subjected to SMA-12 and electrophoretic analyses. In this way, degree of under-nutrition--or other physiological problems--can be specifically noted.

Hematological analyses seem less promising for such purposes.

3. Responses of serological and hematological parameters to physiological and behavioral stress (and therefore the values of these parameters as indicators of stress) should be tested in one enclosure (Pen 4) by introducing an abnormally high population density into the pen. Limiting factors (ie: will moose ever reach density sufficient to hedge vegetation or will other factors depress densities below this level?) will also be more clearly elucidated by this experiment.

4. Present methods of estimating browse utilization are inadequate. A full-time plant ecologist or range manager should be assigned to develop a workable and precise technique.

PUBLICATIONS

Results of blood analyses will be published as a single paper, possibly in Comp. Biochem. Physio.

Pen layout, stocking and general programs will be published as the basis for a MRC series.

LITERATURE CITED

Bassett, N. R. 1951. Winter browse utilization and activities of moose on the Snake & Buffalo river bottoms of Jackson Hole, Wyoming. M.S. Thesis. Utah State Ag. College. 79 p.

Bischoff, A.I. 1954. Limitations of the bone marrow technique in determining malnutrition in deer. Proc. Western Assoc. State Game & Fish Comm. 34:48-52.

Bishop, R. H. 1969. Moose Report. Annual Project Segment Report. Vol. X. W-15-R-3, Work Plan K. 152 p.

Braend, M. 1962. Studies on blood & serum groups in the elk (*Alces alces*). *In*: Blood Groups in Infrahuman Species (ed: Chone, C.) An. N.Y. Acad. Sci. 97:296-305.

Cheatum, E.L. 1949. Bone marrow as an index of malnutrition in deer. N.Y. State Conservationist. 3(5):19-22.

Coles, E.H. 1964. Veterinary clinical pathology. Saunders, Philadelphia. 455 p.

Cook, H. W., Rausch, R. A. & B. E. Baker 1970. Moose (*Alces alces*) milk. Gross composition, fatty acid, & mineral constitution. Can. J. Zool. 48:213-215.

Cowan, I. McT. *et al*. 1950. The effect of forest succession upon the quantity & upon the nutritive values of woody plants used as food by moose. Can. J. Res. 28:249-271.

Daubenmire, R. 1959. A canopy-cover method of vegetational analysis. Northwest Science. 33 (1):43-64.

Davidson, I. & J.B. Henry. 1969. (ed.) Clinical Diagnosis. Saunders, Philadelphia. 1308 p.

Denniston, R. H. 1956. Ecology, behavior & population dynamics of the Wyoming or Rocky Mountain moose. Zoologica 41:105-108.

Glass, R. L. *et al*. 1967. Comparative biochemical studies of milk. IV. Constituent fatty acids of milk fats. Comp. Biochem. Physiol. 22:415.

Greer, K.R. 1968. A compression method indicates fat content of elk (wapiti) femur marrows. J. Wildl. Mgmt. 32(4):747-751.

Harry, G.V. 1957. Winter food habits of moose in Jackson Hole, Wyoming. J. Wildl. Mgmt. 21:53-57.

Herin, R.A. 1968. Physiological studies in the Rocky Mountain elk. J. Mammal. 49:762-764.

Houston, D.B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natural History Assoc. Tech. Bulletin No. 1. 110 p.

__________. 1969. A note on the blood chemistry of the Shiras moose. J. Mammal. 50:4 p.

Kitts, W.D. *et al*. 1956. Effect of age & plane of nutrition on the blood chemistry of the Columbian black-tailed deer. (*Odocoileus hemionus columbianus*. II. Packed-cell volume, sedimentation rate, & haemoglobin. Canadian J. Zool. 34:477-484.

Knowlton, F.F. 1960. Food habits, movements & populations of moose in the Gravelly Mountains, Montana. J. Wildl. Mgmt. 24:162-170.

Knorre, E.P. 1961. The results and perspectives of domestication of moose. Papers of the Pechora-Ilch State Reservation: IX. 263 p.

LeResche, R.E. 1968. Spring-fall calf mortality in an Alaskan moose population. J. Wildl. Mgmt. 32:953-956.

Markgren, G. 1969. Reproduction of moose in Sweden. Viltrevy. 6:129-299.

McMillan, J.F. 1950. Summer food habits of moose & effects of various factors on food supply in Yellowstone National Park. Ph.D. Thesis, U. Michigan. 170 p.

Nadler, C.F. *et al*, 1967. Electrophoresis of the serum proteins and transferrins of *Alces alces* (moose), *Rangifer tarandus* (reindeer), and *Ovis dalli* (Dall Sheep) from North America. Comp. Biochem. Physio. 23:149-157.

Murphy, D.A. & J.H. Coates. 1966. Effects of dietary protein on deer. Trans. N. Amer. Wildl. Conf. 31:129-138.

Neiland, K.A. 1970. Disease & parasite studies. Annual Project Segment Report. Vol. XI. Project W-17-2, Work Plan R. 36 p.

Pimlott, R.H. 1956. Ecology, behavior & population dynamics of the Wyoming or Rocky Mountain moose. Zoologica 41:105-108.

Rausch, R.A. 1959. Some aspects of the population dynamics of the railbelt moose population, Alaska. M.S. Thesis, Univ. of Alaska. 71 p.

Rausch, R.A. & R.H. Bishop. 1968. Report on 1966-67 moose studies. Annual Project Segment Report. Vol. VIII & VIX. W-15-R-3-3. Work plan K. 263 p.

Rausch, R. A. & A.E. Bratlie. 1965. Assessments of moose calf production & mortality in Southcentral Alaska. Proc. Western Assoc. State Game & Fish Commissioners. 45:11 p.

Seal, U.S. & A.W. Erickson. 1969. Hematology, blood chemistry & protein polymorphisms in the white-tailed deer (Odocoileus virginianus). Comp. Biochem. Physiol. 30:695-713.

Simpkin, D.W. 1965. Reproduction & productivity of moose in northwestern Ontario. J. Wild. Mgmt. 29:740-750.

Spencer, D.L. & J. Hakala. 1964. Moose and fire on the Kenai. Proc. Third Ann. Tall Timbers Fire Ecology Conf. Tallahassee, Florida

Verme, L.J. 1962. Mortality of white-tailed deer fawns in relation to nutrition. First Natl. Deer Disease Symposium Proceedings. U. Georgia; Athens. p 15-29.

________ 1963. Effect of nutrition on growth of white-tailed deer fawns. Trans. N. Amer. Wildl. Conf. 28:431-443.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Alaska Department of Fish and Game, U.S. Bureau Sport Fisheries and Wildlife, Kenai NWR

Project No.: W-17-2 Project Title: Moose Investigations

Job No.: 1.2R Job Title: Moose Behavior

Period Covered: July 1, 1969 through June 30, 1970

SUMMARY

Two hundred sightings of 185 tagged adult moose on the Kenai Peninsula revealed a migratory pattern of movement to highlands in late summer and fall and return to lowlands in late winter. Pattern of recoveries suggests a smaller older migratory population superimposed on a dense resident population.

Significant seasonal changes in directional tendency of penned animals suggest that seasonal movements are at least partially due to internal stimuli.

Three tame yearling moose were acclimated to human presence and a method was formulated to record their feeding habits bite-by-bite.

Behavior of 4 pregnant and 4 non-pregnant cows was observed during and after the calving period.

CONTENTS

BACKGROUND

Moose in the lower and more accessible areas of the Kenai National Moose Range receive considerable hunting pressure and in late fall exhibit a low proportion of bulls in the population, as shown by aerial sex and age composition counts. Production of calves as observed at the same time is some years not as high as anticipated. Although in much of the area browse (mainly birch) is in abundance, substantial numbers of moose have died in severe winters. Population estimates by personnel of the Kenai National Moose Range suggest substantial numbers of moose, but concern has been expressed regarding the numbers and welfare of the moose inhabiting the "lowlands", especially in relation to hunting pressure.

The moose traditionally using the foothills and mountains but wintering on the lowlands receive little hunting pressure and appear to be relatively more abundant according to Kenai National Moose Range staff reports. These moose characteristically exhibit a high ratio of bulls to cows and a low proportion of calves.

However, the "lowland population", or those moose still in the flats during late summer and fall, while having relatively more calves, exhibit a low (usually less than 20:100) bull:cow ratio. Yet most cows appear to be bred (pregnancy of less than 90% in winter has never been recorded), and numbers seem to remain fairly high year round. For example, when the gates to the enclosures were closed, 30 moose were enclosed in 2 square miles in August.

The objective of this part of the job is to delineate the various populations and sub-populations present and to learn migratory behavior of those animals that do migrate. Goddard (1970) reported on a movement study in Ontario similar to this one. His recoveries were few in relation to his large number (318) of marked moose, but he did document movement between summer and winter ranges (which had been done many times before, <u>cf</u>: Edwards and Ritcey 1956, Kraft 1964 and Houston 1968) as well as suggesting there was no net movement into heavily hunted areas. Bishop (1970) reported that a Tanana Flats population identity study pursued by calf tagging suggested that both migratory and resident individuals were present in those lowlands. Didrickson (pers. comm) reported adult moose in the Matanuska Valley moved nearly 60 miles on occasion.

Browse utilization studies (<u>cf</u>: Job 1.1) suffer from being confined to studies of woody stems, where browsing leaves evidence that can be later recorded. In order to study utilization of forbs, grasses, sedges and small woody and perennial plants, tame moose were raised and observed.

Calf mortality is greatest within several weeks <u>post-partum</u> (LeResche 1968). This mortality may be partially due to nutritional deficiencies. However, immediate causes are often behavioral. Previous research (LeResche 1968) depended upon chance observations of marked calves, rather than upon regular assured observations.

OBJECTIVES

1. To identify populations and learn seasonal patterns of movements by moose on the Kenai Peninsula.

2. To determine what species of browsed and grazed plants are taken in what pattern by moose.

3. To determine behaviorally-related causes of early calf mortality.

PROCEDURES

1. Population Identity and Movement: Table 21 lists adult moose marked in October 1968 at Mystery Creek ("highlands"), in March 1970 (Bottenintnin Lake) and June 1970 (Moose River Flats) and August 1969 through June 1970 at the MRC--all lowlands. The moose represent 1) a rutting group, 2) a late-winter concentration, 3) a post-calving concentration, and 4) year-round flatland residents. Fig. 19 shows tagging areas relative to one another and to physiographic features.

Table 22 lists reconnaissance-counting flights made by Alaska Department of Fish and Game personnel. Several additional flights were made by R. Richey, U.S. Bureau Sport Fisheries and Wildlife.

Moose were tagged using helicopters and succinylcholine chloride. Groups were separated by using different colored ear-flags and/or collars during each tagging effort. Ear flags were put in females' right ears and males' left ears. Large numbered pendants were placed on the animals tagged at Moose River Flats in June 1970. Moose tagged at the Moose Research Center were captured in fenceline traps. All observations of moose along fencelines within MRC enclosures were recorded by date and location and tabulated to reveal migrational tendency.

2. Tame Moose Feeding Study: Two male calves were obtained from Dr. Jack Luick, Institute of Arctic Biology, in October 1969. A single female the same age was given by the same source in April 1970. Observations during this report period were informal and directed at acclimating the calves to close human presence and developing a recording method for feeding observations. Twenty-four hours per week were spent recording feeding habits, beginning July 1, 1970.

3. Cow Behavior Affecting Early Calf Mortality: Radio-tracking transmitters were installed on 8 cows in April and May. These were located daily through May and early June and periodically at irregular intervals thereafter. A graduate (M.S.) student from the Alaska Cooperative Wildlife Research Unit initiated a maternal-calf behavior study using these radio-collared moose.

FINDINGS

1. Population Identity and Movements: Table 23 lists the 200 sightings of marked moose made since October 1968. The majority of the sightings have been

Table 21. Adult moose marked on Kenai Peninsula, October 1968 through June 1970

	Males	Females	Sex(?)	Total
Mystery-Dike Creek(highlands) October 1968	10	18	0	28
Bottenintnin Lake(lowlands) March 1970	16	52	1	69
Moose River Flats(lowlands) June 1970	26	43	2	71
Moose Res. Cntr.(lowlands)	1	15	(1 F calf)	17
	53	128	4	185

Color Codes

	Male		Female		
Area	Collar	Ear	Collar	Ear	Pendants
Mystery Creek	Yellow	Left Orange	Red	Right Orange	None
Bottenintnin Lake	Blue	Left Orange	White	Right Orange	None
Moose R. Flats	Blue	Left Green	White	Right Green	Red A1-A100
MRC	Blue	Left Silver	White	Right Silver	White 51-100

Figure 19. Diagramatic layout of moose tagging areas.

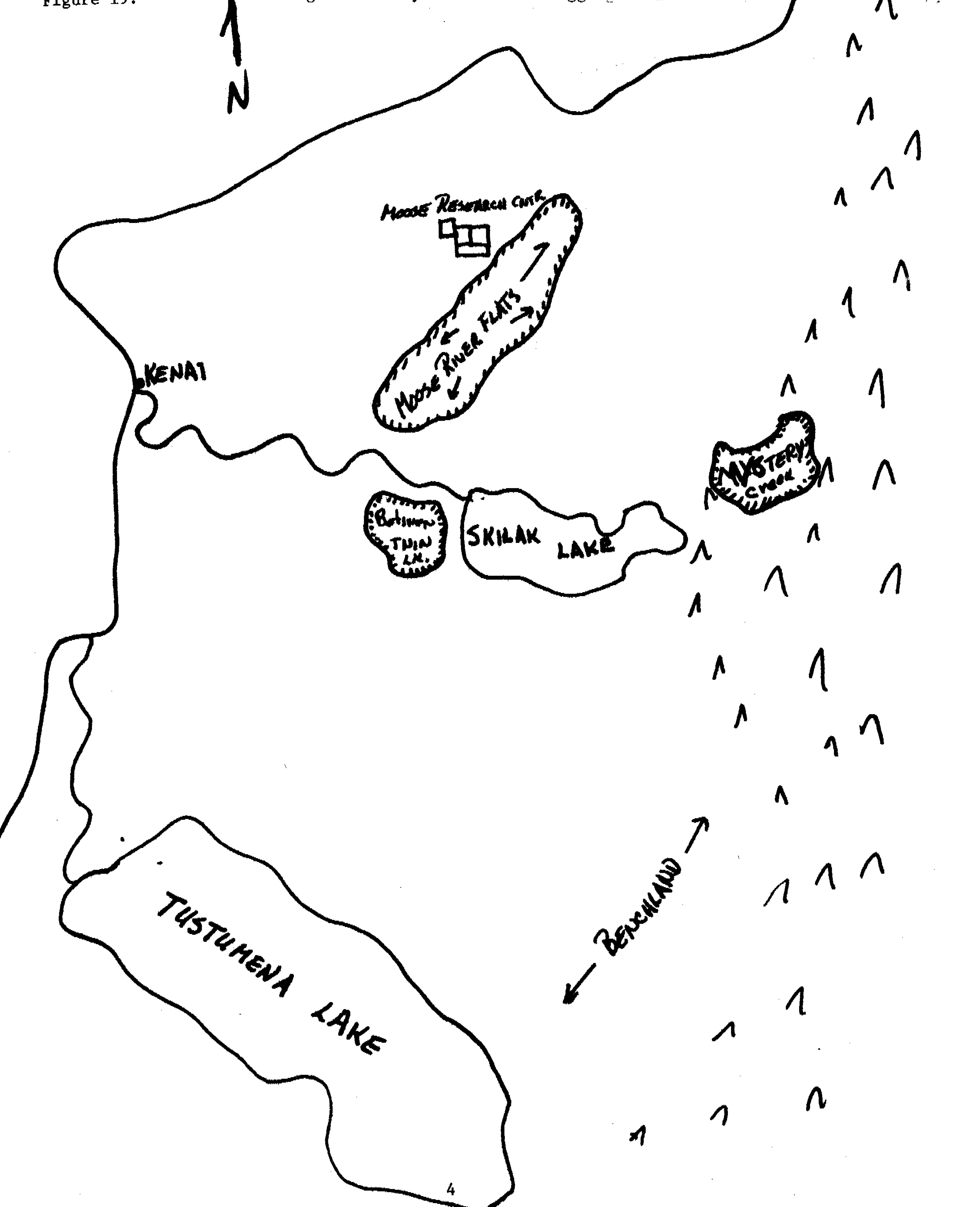


Table 22. Reconnaissance flights by ADF&G searching for collared moose.

Date	Area	Collared Moose Located*
26 March 1970	Skilak Lake N. of Kenai R.	12 BL
31 March 1970	Same	10 BL
3 April 1970	Same	6 BL
6 April 1970	Same	4 BL
6 April 1970	South of Kenai River to benchland	0
6 April 1970	North of Sterling Hwy. 0-5 miles	3 BL; 1 MRC
8 April 1970	Skilak Lake area	4 BL
14 April 1970	Moose R. Flats	1 MRC
14 April 1970	Skilak Lk. area	7 BL
22 April 1970	Same	6 BL
24 April 1970	Moose R. flats, Hidden Lk. Skilak Lk.	0
27 April 1970	Moose R. flats to Sterling Hwy.	0
4 May 1970	Mystery Creek	0
4 May 1970	Skilak Lk. area	6 BL
11 May 1970	Moose R. flats; upper Funny R.	0
11 May 1970	Skilak Lk. area	6 BL
17 May 1970	Tustumena-Skilak benchland + Skilak area	0
1 June 1970	Moose River flats	1 MC
1 June 1970	Skilak Lk. area	1 BL

* Code: Tagged at Mystery Creek: MC
Tagged at Bottenintnin Lake: BL
Tagged at Moose River Flats: MRF
Tagged at Moose Research Center: MRC

Table 23. Number of sightings of adult moose tagged on the Kenai Peninsula. Sightings through 30 June 1970.

Tagging Location (date)	Females	Males	Total
Mystery Creek X/68	70	16	86
Bottenintnin Lake III/70	63	9	72
Moose Research Center IX/69-VI/70	12	3	15
Moose River Flats VI/70	22	5	27
	167	33	200

made by R. Richey (USFWS) throughout the period and by ADF&G biologists since March 1970, when weekly flights were initiated. To date, no final conclusions are warranted since major tagging occurred only near the end of the reporting period. However, some tentative observations are in order, using information from Mystery Creek animals and clues from recent tagging observations. Table 24 lists general locations of the 83 sightings of Mystery Creek moose by month: October, 1968 through June, 1970. Observations are biased somewhat by the irregularity of searching effort before 1970, but the seasonal migration pattern (cf: Fig. 20) is nonetheless discernable. Generally, August through December is spent in the highlands and January through July in the Moose River Flats or along the Sterling Highway (nb: that the unshaded area in the figure is probably disproportinately large because of the comparatively great observer-time along the highway).

Within this pattern, certain individuals have rigid personal routes of migration. One large bull, tagged at Mystery Creek, was observed 5 times in May-June, 1969 along the east shore of Moose Lake (16 miles N.W.). In August and October 1969, the same bull (identified by antler form) was twice seen at the original tagging site. The next May and early June, he was seen twice at Moose Lake, twice just south of the MRC (5 miles S.W. Moose Lake), and once, in late June, midway between the MRC and the original tagging site.

Few if any moose remain in the Mystery Creek and similar highlands in late winter and few reappear until late July in most years. However, the existence of a substantial resident (non-migratory) population in the Moose River Flats - 1947 burn area - is becoming apparent. In August 1969, the enclosing of Pens 3 and 4 at the MRC confined a minimum of 30 animals in the 2 square miles. Of 15 sightings between September 1969 and June 1970 of MRC-tagged individuals, (moose tagged in fenceline traps outside the MRC enclosures) all but 3 have been within one mile of the pens. (Two cows were sighted in April 13 miles West and one bull in November 9 miles South.) A decrease in density in the calving and burn areas is apparent in July and August, but high densities of moose do remain.

Maximum movements of Mystery Creek-tagged animals are by a female seen 23.5 miles N.W. of the site 13 months after tagging, and by several females seen near the Sterling Highway as far east as Kenai and Summit Lakes (22 miles distant).

The distinction (if any) between moose seen in the Moose River calving flats in May and June and those concentrated just north of Skilak Lake in February - mid May (they disappear in large part by late May) is an important and still unsolved problem. As early as April, a few animals (cf: 3 on 6 April) tagged at Skilak were observed to have moved north toward areas of calving concentration. Yet, age composition of the two groups at tagging (Fig. 21) is significantly ($P > .01$, $X^2 \approx 28.455$, $n = 13$) different. Perhaps the dilution of a large resident population by a smaller migratory and older population is insufficient to appreciably alter the age structure of the former.

2. "Migrational Tendency" of Enclosed Moose: Results of directional analyses of moose observations along fencelines within the MRC are given in Fig. 22. That confined animals differ significantly (X^2 testing) by

Table 24. General areas of 83 sightings of moose tagged in Mystery Creek highlands, by month, October 1968-June 1970.

	Mystery Creek Highlands		Sterling Highway East of Mystery Creek		Moose River Flats	
	Females	Males	Females	Males	Females	Males
January			6	1	1	
February			7		3	
March	1		4	1	1	
April			6			
May			2		2	3
June		1	10		5	7
July			5			
August	1	1				
September			1			
October	3	1				
November	1		2	1	1	
December	2		1		2	

Figure 20: Percentages of observed Mystery Creek tagged moose in Mystery Creek highlands (heavy crosshatch), along highway East of Mystery Creek (unshaded), and on Moose River Flats (large squares and dots).

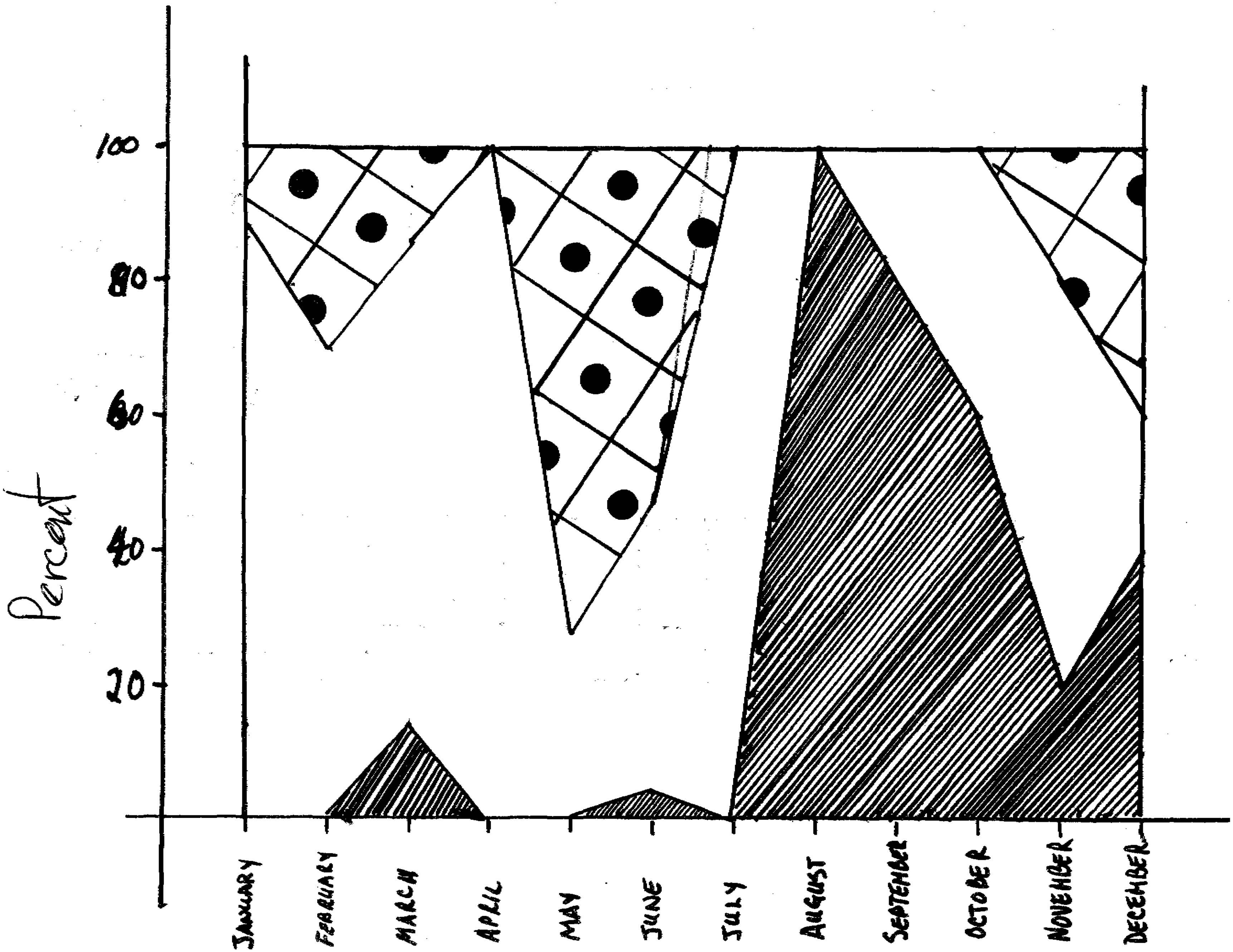


Figure 21: Moose River Flats - Bottenintnin Lake

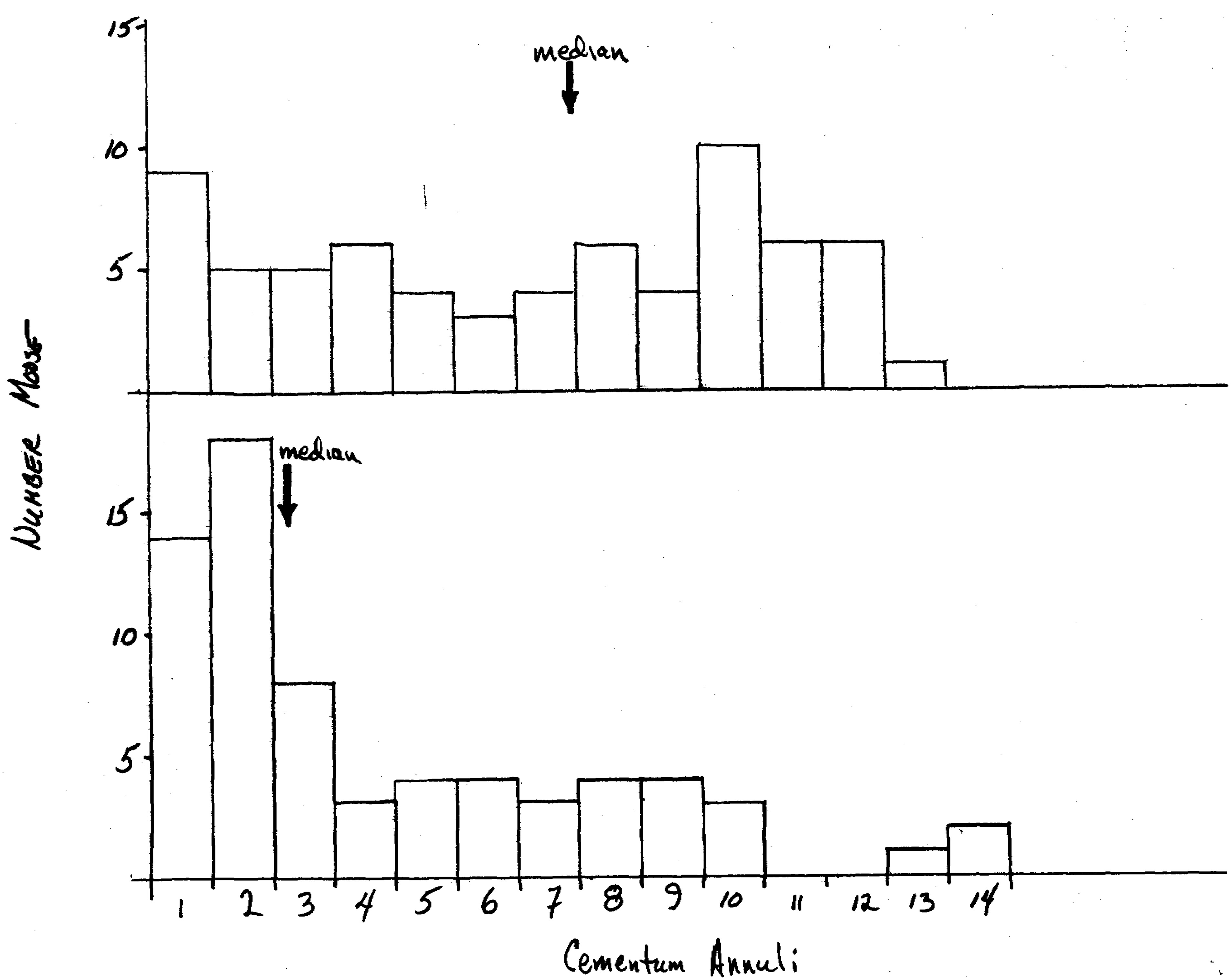
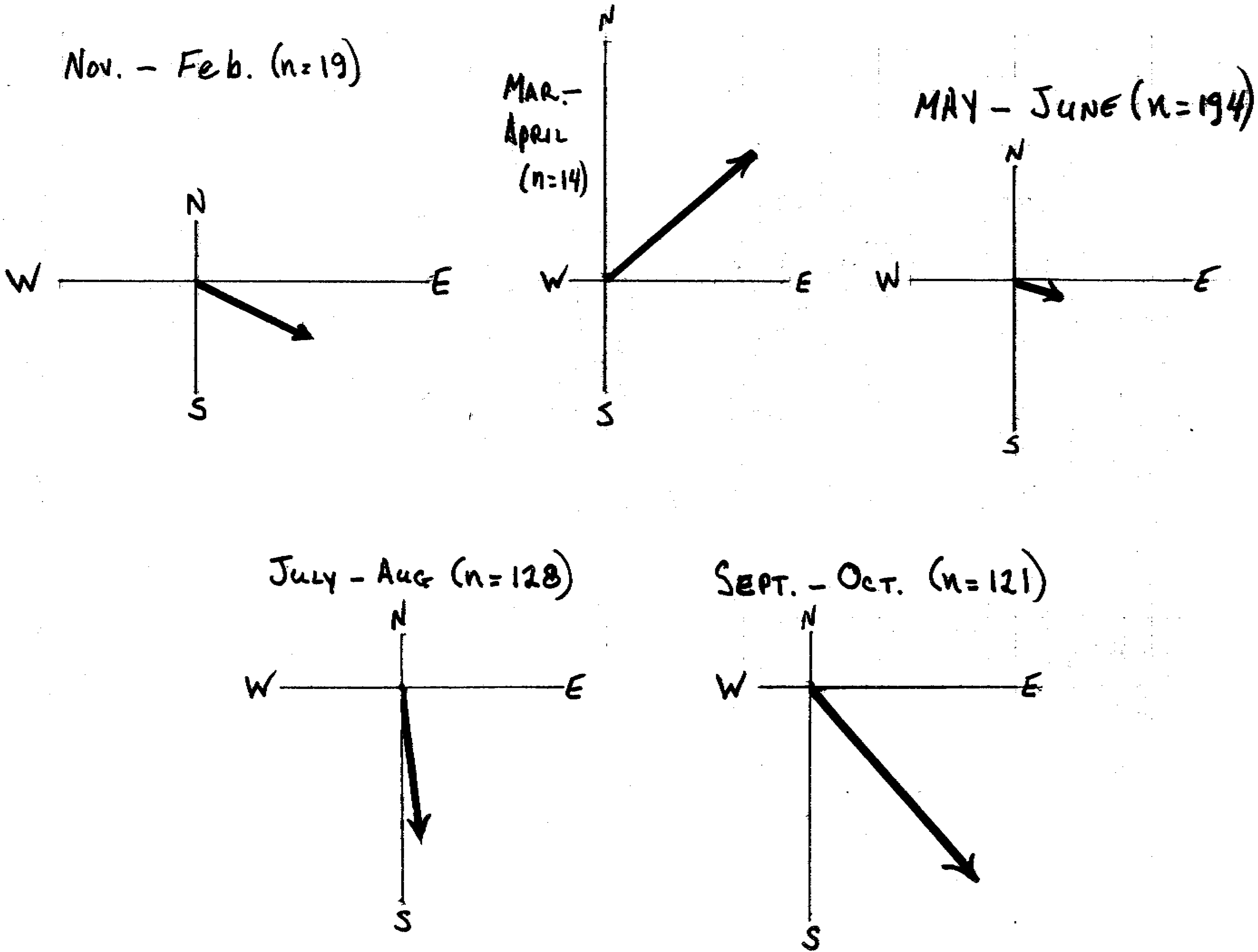


Figure 22: Directional tendencies of 476 observations of moose along Moose Research Center enclosure fences. June 1969-June 1970.



season in directional tendency suggests that seasonal movements in moose are indeed "migratory" in the true sense: ie, internally triggered rather than resulting entirely from food/snow conditions.

The resultant directions (Fig. 22) agree with the concept of a population moving toward highland areas in July-October (mainly, S.E. from the MRC) and back to flatland calving areas (more northerly from wintering areas) in March and April. The easterly trend in the figure is more apparent than real, for east vs west differences are statistically insignificant $P < .10$) from November through April.

3. Tame Moose Feeding Observations: Formal observations were not begun during this reporting period. IBM optical page reader sheets were designed. The sheets record: for each plant eaten - 1) species 2) hedged class 3) total height and 4) basal diameter--for each bite taken - 1) number of leaves or size of twig taken 2) diameter of stem browsed 3) browse condition of individual leader and 4) height above ground of individual leader. In addition, the sheets record activity patterns (they are timed and non-feeding periods are included) and spatial distribution of browsing (they record changing plant-plant and leader-leader). Regularly scheduled observations began July 1, 1970.

RECOMMENDATIONS

Reconnaissance flights throughout Subunit 15A should be continued weekly to derive maximum information from tagged animals. More moose should be tagged in late winter concentration areas near the Sterling Highway to adequately define calving and rutting areas of these animals.

Moose should be tagged in fall in Skilak-Tustumena benchland and Caribou Hills areas to determine wintering areas of these trophy-class populations.

In the interim, seasons should be set with the following probabilities in mind:

1. Late summer and fall "highland" populations are likely older animals, fewer in number than the substantial lowland resident populations.

2. Populations are predictable in their movements: therefore, harvest of various groups can be controlled by properly timed field announcement hunts.

3. Even though migratory populations may be adequately harvested (on a maximum sustained yield basis) local resident populations in the 1947 burn remain essentially unharvested with present access.

PUBLICATIONS

Results will be published when work is complete enough to warrant it.

LITERATURE CITED

Bishop, R. H. 1970. Changes in composition of the Tanana Valley moose herd. Paper presented VIth. Annual N. A. Moose Meeting, Kamloops, B.C.

Edwards, R. Y. & R. W. Ritcey. 1956. The migrations of a moose herd. J. Mammal. 37:486-494.

Goddard, J. 1970. Movements of moose in a heavily hunted area of Ontario. J. Wildl. Mgmt. 34:439-445

Houston, D. B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natural History Assoc. Tech. Bulletin No. 1. 110 p.

Kraft, A. 1964. Management of moose in a Norwegian forest. Norwegian State Game Research Inst. Series 2: No. 16. 61 p.

LeResche, R. E. 1968, Spring-fall calf mortality in an Alaska moose population. J. Wildl. Mgmt. 32:953-956.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Alaska Department of Fish and Game, U. S. Bureau of Sport Fisheries and Wildlife, Kenai NWR

Project No.: W-17-2 Project Title: Moose Investigations

Job No.: 1.3R Job Title: Development and Testing of New Techniques

Period Covered: July 1, 1969 through June 30, 1970

SUMMARY

Inexperienced observers flying intensive aerial surveys observed a mean of 19 percent and 44 percent of enclosed moose in poor and good (respectively) counting conditions. Experienced observers saw 40 percent and 61 percent in poor and good conditions. Significant differences in proportions of moose observed occurred between experienced and inexperienced observers in both good and poor conditions and between good and poor conditions with both experienced and inexperienced observers.

A pellet-count technique using 8 x 24-foot permanent browse-sampling plots appears feasible after estimating N from s^2 derived by counting and clearing the plots.

A moose trap was designed and 11 were constructed. Overall trap success was 26 percent.

M-99 Etorphine and M 50-50 Diprenorphine were found to be excellent drugs for immobilizing moose. Twenty-four moose were handled using them, and 170 with 'Anectine'.

Radio-tracking collars allowed easy location of moose within the MRC enclosures.

Workers within pens containing 46 moose saw a mean of one moose each 14.9 hours.

CONTENTS

CONTENTS (Cont.)

BACKGROUND

Moose research and management require methods of estimating numbers and of handling, marking and following animals. These techniques necessarily vary with species and location of the management/research problem. The Moose Research Center, with known numbers of confined animals, provides a unique test-ground for numbers-related techniques and for methods and equipment whose effectiveness can only be estimated by relocation of animals.

Aerial censusing at present is the only practical method of estimating moose numbers in most of Alaska (cf: Rausch & Bratlie 1965, Rausch & Bishop 1968, Bishop 1969), but the extent to which this method underestimates numbers has been a major problem when absolute numbers are sought. Siniff & Skoog (1964) developed a random stratified, quadrat sampling method, but even in intensively counted quadrats, some animals were missed. The presence of 4 one-square-mile pens with known numbers of moose provided an opportunity to test the accuracy of aerial censusing and to test the value of previous experience in aerial counting.

Pellet-count census techniques have been used for various species of big game animals since the 1930's (cf: Bennett et al 1940; Rasmussen & Dovan 1943). Several studies have been done with penned ungulates (summary in Neff 1968). The known numbers of animals enclosed in the MRC provided opportunity to test this population-estimation technique for moose.

Need to capture and recapture moose for marking and serial blood sampling necessitated the design of a trap. Taber & Cowan (1969) have reviewed designs of traps for various game animals.

Immobilization of big-game animals by drugs has progressed rapidly in a very few years, with different drugs indicated for different species (cf: Harthoorn 1965, Houston 1969). An ideal immobilizing drug should have 1) short induction time, 2) wide tolerance range, 3) rapid reversibility,

4) no lasting or cumulative side-effects. To find such a drug for a given animal, the logical approach is to try agents as they become available, preferably on recoverable animals.

Migration and other behavioral studies of big game animals may be accomplished by marking many animals and searching for same. Recently, radio-tracking devices have come into vogue for continuous location of animals (cf: Slater 1963 for one review). In programs requiring regular relocation of moose for sampling blood or other specimens, radio tracking gear is invaluable to insure timely recapture.

OBJECTIVES

To develop and/or test techniques for: aerial censusing, pellet-count censusing, trapping, immobilizing, radio-tracking and marking of moose.

PROCEDURES

On January 26 - February 4, 1970, three helicopter counts and 19 counts by PA18-150 supercubs were made of the 4 MRC pens. Observers were instructed to direct pilots how to fly the survey and were allowed 15 minutes to count each square mile. Conditions were good-excellent, with snow cover at least adequate for 15 counts, and poor for 4.

Seven hundred twenty-eight permanent 8' x 24' browse-utilization plots were used as pellet-count plots. Fecal groups in each plot were classified as "winter" (pellets) or "summer" (non-pelletized), counted and cleared from the plot. Data analysis was by habitat type and an estimate was made of required sampling intensity. Pellet groups in two pens were separated into "new" (the preceding winter) and "old" by guess, and endurance of pellet groups was estimated from these data. A habitat use index was calculated from numbers of pellet-groups.

A successful trap was designed and eleven were completed during the report period. Ninety-five moose were handled as a result of 370 trap sets.

M-99 Etorphine and M50-50 Diprenorphine were tested on 24 trapped animals during the period. An additional 170 moose were immobilized by succinylcholine chloride.

Radio transmitters in the 30 mhz range were tested on 10 moose during the report period.

Canvas-webbing collars, pendants, Ritchey ear-tags and "jumbo roto tags" were tested for permanence, legibility and ease of installation on 193 moose. Metal ear-piercing "hasco" tags and "saflag" streamers continued to be used.

Personnel reading browse plots in April 1970 were instructed to watch for moose in the 4 one-square-mile enclosures, where 46 moose were enclosed. One man spent 22 hours mock hunting in the same area. Numbers of moose seen were recorded as an indicator of moose observability.

FINDINGS

Aerial census evaluation: Tables 25 and 25A summarize proportions of moose seen by aerial counters in the 4 one-square-mile pens. Using PA-18-150 supercubs, four experienced observers observed 61 percent of the 49 enclosed moose; whereas 11 inexperienced observers saw only 44 percent (difference significnant $P < .01$). Three experienced observers counting under poor conditions (insufficient snow cover) located 40 percent of the moose flown over (different significantly $P < .01$ from experienced observers/good conditions). An inexperienced observer flying in poor conditions saw only 9 of 48 (19 percent) moose.

Thus, under good conditions experienced observers locate only 60 percent of moose flown over, even when spending much more time than is usually the case in aerial surveys. Considering that the pilot participates in standard surveys, efficiency might be improved, yet almost never is one square mile circled for fifteen minutes.

Pens varied significantly ($P < .01$) in percent moose seen. Some variation is possibly due to vegetation and topography; but, in addition, in the pen (No. 1) with fewest moose enclosed, observers saw the greatest percentage of animals and in the pen (No. 4) with most enclosed, they saw the least, proportionately.

The results suggest that strict comparison of aerial count results year-to-year or place-to-place when any variables in observers, conditions, topography, or moose densities exist is dangerous at best.

Pellet-count census technique: Table 26 summarizes data for all fecal groups cleared from the 728 plots. It also estimates required N to achieve results within a 20% selected risk of error (see Neff 1968). The required N, less than 200 per square mile in all cases, is within reason, indicating that the technique is feasible. However, the final proof requires reading of the plots next spring to determine new groups deposited during the year and to correlate this with the number of moose in individual pens. Correlation with numbers of moose was not attempted with uncleared plots.

Pellet group permanence, as estimated from proportion of "new" groups in Pens 1 and 2 was 0.328. Thus approximately one third of groups present were deposited the preceding year, and, if groups disappear at a constant rate, one third disappear each year.

Moose defecation rate was estimated by Edwards (cf: Neff, 1968) as 13.0/day. Using our estimated proportion of new groups in Pens 1 and 2, expanding by total groups/moose in all four pens and using a 210 day "winter" estimator, our data estimate 10.3 groups/moose/day.

Table 27 summarizes habitat use as estimated from numbers of pellet groups and "summer" fecal piles in the seven habitat types. Indices are based upon assigning a value of 1.00 to the habitat type with most pellet groups per plot (medium-birch in each case). Habitat use estimated from defecation agrees generally with use for feeding, estimated from twig utilization. Spruce-birch, a habitat type useful for concealment, is the

Table 25: Numbers and proportions of moose seen in four one-square-mile enclosures by nine experienced and twelve inexperienced observers flying fifteen minutes/square mile in PA-18-150 aircraft. January-February 1970.

Observer Category	Conditions	Pen (n)				Total
		I (7)	II (12)	III (12)	IV (18-17)	(n = 49-48)
Pilot	Good	7 (1.00)	--	7 (.58)	10 (.56)	24 (.65)
Pilot	Good	7 (1.00)	9 (.75)	10 (.83)	13 (.72)	39 (.80)
Experienced	Good	4 (.51)	5 (.42)	8 (.67)	7 (.39)	24 (.49)
Experienced	Good	6 (.86)	7 (.58)	8 (.67)	9 (.50)	30 (.61)
Experienced	Good	7 (1.00)	8 (.67)	10 (.83)	12 (.67)	37 (.76)
Experienced	Good	6 (.86)	7 (.58)	6 (.50)	10 (.56)	29 (.59)
Experienced	Poor	4 (.57)	3 (.25)	6 (.50)	8 (.47)	21 (.44)
Experienced	Poor	0 (.00)	6 (.50)	6 (.50)	5 (.30)	17 (.35)
Experienced	Poor	5 (.71)	3 (.25)	4 (.33)	7 (.41)	19 (.39)
Inexperienced	Good	4 (.57)	5 (.42)	4 (.33)	6 (.33)	19 (.39)
Inexperienced	Good	4 (.57)	5 (.42)	4 (.33)	4 (.22)	17 (.35)
Inexperienced	Good	0 (.00)	4 (.33)	6 (.50)	3 (.17)	13 (.27)
Inexperienced	Good	5 (.71)	4 (.33)	7 (.58)	12 (.67)	28 (.57)
Inexperienced	Good	2 (.29)	10 (.83)	4 (.33)	8 (.44)	24 (.49)
Inexperienced	Good	5 (.71)	7 (.58)	5 (.42)	10 (.56)	27 (.55)
Inexperienced	Good	6 (.86)	4 (.33)	4 (.33)	5 (.30)	19 (.39)
Inexperienced	Good	3 (.43)	4 (.33)	6 (.50)	6 (.33)	19 (.39)
Inexperienced	Good	4 (.57)	3 (.25)	8 (.67)	5 (.30)	20 (.41)
Inexperienced	Good	4 (.57)	7 (.58)	5 (.42)	6 (.33)	22 (.45)
Inexperienced	Good	7 (1.00)	8 (.67)	6 (.50)	9 (.50)	30 (.61)
Inexperienced	Poor	1 (.14)	3 (.25)	3 (.25)	2 (.12)	9 (.19)

Table 25A: Summary of mean proportions of moose observed in four one-square mile enclosures by observer, weather conditions and aircraft. January-February 1970. (Each square-mile searched fifteen minutes.)

Observer (n)	Conditions	Aircraft	Pen (n)				Total (n)
			I (7)	II (12)	III (12)	IV (18)	
Pilots (2)	Good	PA 18-150 Supercub	1.00	.75	.71	.64	.73 (49)
Experienced (4)	Good	PA 18-150 Supercub	.82	.56	.67	.53	.61 (49)
Experienced (3)	Poor	PA 18-150 Supercub	.43	.33	.44	.39	.40 (48)
Inexperienced (11)	Good	PA 18-150 Supercub	.57	.46	.45	.37	.44 (49)
Inexperienced (1)	Poor	PA 18-150 Supercub	.14	.25	.25	.12	.19 (48)
Experienced* (3)	Good	BG 4A Helicopter	.93	.78	.58	.80	.75 (48)

* 2 Observers

Table 26. Pellet groups removed from 728 - 8 x 24 foot plots randomly selected by habitat type. Kenai Moose Research Center. April, 1970. N 20% is the estimated number of plots needed to sample for a 20% risk of error.

	Birch			Spruce		Mature Hardwoods		All	N 20%
	Dense	Medium	Thin	Spruce-Birch	Spruce	Dense	Thin		
Pen 1									
n	22	25	25	24	20	19	21	157	
$\bar{x}$	.409	1.00	0.84	0.92	0.65	0.21	0.43	0.67	196
s	.651	1.44	1.08	0.95	0.73	0.52	0.58	0.97	
Pen 2									
n	32	31	31	22	30	21	26	191	
$\bar{x}$	0.53	0.68	0.39	0.23	0.27	0.33	0.15	0.39	152
s	0.83	1.06	0.75	0.60	0.51	0.47	0.46	0.74	
Pen 3									
n	25	25	25	25	25	25	25	175	
$\bar{x}$	1.08	0.88	0.48	0.60	0.72	0.32	0.52	0.66	153
s	0.89	0.91	0.64	0.63	0.96	0.55	0.80	0.82	
Pen 4									
n	25	26	19	24	26	24	31	175	
$\bar{x}$	1.00	2.15	0.89	1.71	0.62	0.38	0.74	1.09	162
s	1.10	2.09	1.45	1.81	0.84	0.63	0.98	1.52	

Table 27. Habitat-use indices for seven habitat types, derived from pellet-count data. Kenai Moose Research Center, April 1970

	Winter	Summer	All Year
Medium Birch	1.00	1.00	1.00
Dense Birch	.73	.44	.65
Spruce-Birch	.68	.62	.67
Thin Birch	.54	.37	.50
Spruce	.40	.56	.44
Mature Hwds. Thin	.39	.41	.40
Mature Hwds. Dense	.28	.06	.23

only type elevated in defecation use above feeding use. Dense- and thin-birch types both decrease in usage (relative to medium birch) during summer, whereas use of spruce type (where low shrubby plants--eg: B. nana--are abundant) increases.

Trapping: The trap designed was a pen, 70-100 feet long and 12 feet wide, with one long side part of a fenceline. Swinging gates (8' x 12') were hung from top hinges at each end and tripped to swing out by a trigger-string, stretched across the alley-like runway. Gates fall by gravity and are held in a vertical position after tripping by shock-cord softened lines. The trapped moose is immobilized by Cap-chur gun.

Trap success varied by season (peaks occurred in June-July and September-October, lowest success in January-March) and by trap (range: 18-57 trips/100 trap-nights). Table 28 summarizes success for the ten traps used most extensively during the period. Strengthening of stop cords and refining of the trigger mechanism has reduced escapes and trap failures the past month. Fig. 23 is a stylized diagram of the trap-trigger arrangement.

Immobilizing drugs: M99 Etorphine and M50-50 Diprenorphine were established as drugs-of-choice for handling moose within the MRC enclosure. M 99 was preferable to "Anectine" for its: 1) more rapid induction time (7.5 min. ± 3.4 S.D. for M99 vs 12.5 min. ± 8.4 S.D. for Anectine), 2) greater predictability of induction (cf: above SD's), 3) greater range of safe dosage sufficient to immobilize (3-10 mg/moose for M99; or 230% minimum vs 20-23 mg/moose Anectine, or 20% minimum), 4) rapid reversability (2.5 min. ± 3.2 S.D. vs no reversibility - but recovery times of 37 minutes ± 12 S.D. - for Anectine), 5) greater control of response to M99 (animals could be drugged just enough to be halter-led from place to place and did not suffer from complete collapse and danger of regurgitant drowning as did Anectine-immobilized moose). (Above values are based on N=24 for M99 and n=27 for Anectine--all cases in which response of a captive animal was watched closely and no external factors interfered.)

M99 dosage varied by season. A pregnant cow (wt. = 600 pounds) was killed by 6 mg M99 on May 19, 1970, after being successfully immobilized by 10 mg on October 29, 1969. Another adult female was killed October 23, 1969 by over-dose of the antagonist (M50-50). The antidote was given at 3/1 proportion to M99 rather than the suggested 2/1.

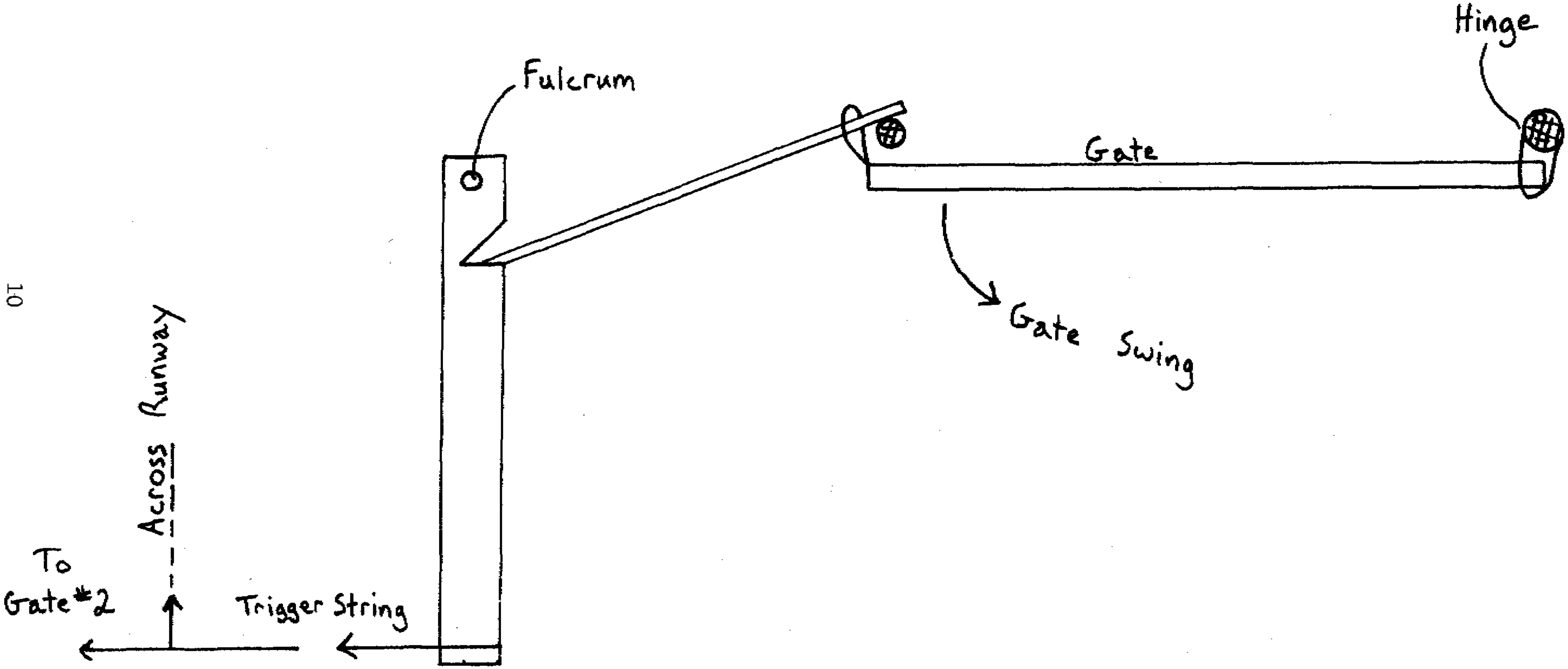
Both these deaths were due to experimentation. With these drugs, 3-4 mg. always produced sufficient effects to approach the animal; the only advantage of increased dosage being more rapid immobilization.

There are several drawbacks to M99 and M50-50 for general use. The user must have a federal narcotics tax stamp. The drugs are not yet available over-the-counter, but must be procured from American Cyanamid Co. on an investigational basis. Such procuring often takes 6-10 weeks. They are dangerous for human handling, as small amounts are toxic. Meat of animals injected with the drugs has not been cleared for human consumption.

Table 28. Trap effectiveness - Kenai Moose Research Center - June 1969 - May 1970

Trap No.	No. Sets	Trips/Set	No. Captured and Handled	Moose/Set	Escape/Set	Trap Failure/Set
1-1	46	.57	16	.35	.07	.13
10-1	39	.23	7	.18	.03	.03
10-3	11	.45	3	.27	.18	.18
2-1	52	.44	16	.31	.08	.04
2-2	55	.33	13	.24	.02	.05
3-1	31	.43	8	.26	.13	.03
3-2	14	.36	2	.14	.07	.07
4-1	45	.51	15	.33	.07	.04
4-2	39	.18	3	.08	.05	0
40-2	38	.47	12	.32	.16	.05
All Traps	370	.40	95	.26	.08	.05

Figure 23: Gate trigger mechanism.



Telemetric tracking: Radio collars and a hand-held receiver were successful in locating at will ten moose within the pens. Battery life was at least one year for one collar and others are still operational after two months. One transmitter failed due to improper tuning. The present system is considered adequate for "belling" moose within the pens, but has been inadequately tested for range of more than one mile.

Miscellaneous: Ritchey large ear-tags, 2" x 2" numbered rubber flaps, were found ideal for legibility and retention (none lost in 11 months) when installed in mooses' ears. Numbers or letter-number combinations are legible at 200 yards with a spotting 'scope.

Jumbo Rototags showed good retention (none lost in 11 months) but were more difficult to read, even when installed in color-coded series of three.

Table 29 shows moose observed by workers known to be within one mile of 7-16 moose. Mean number of hours in the field per moose seen was nearly 15. Even the "hunter" saw but 2 moose away from the fenceline (an unnatural barrier), for a more realistic estimate of $\frac{22}{2}$ or 11 hours/moose.

RECOMMENDATIONS

Aerial censuses should be regarded as only indicative of trends (and even then, only under very similar conditions) and should never be construed to represent anything approaching absolute numbers. Individual observers should be screened carefully and should have as much experience as possible before their data is considered strictly comparable to others. Counting conditions should be good-excellent before counts are made.

Means of censusing and estimating composition of moose populations other than from the air should be sought and tested.

Plots cleared of pellet groups this year should be re-read in April 1971 to determine the ultimate validity of this technique for moose.

One or two moose traps should be constructed along natural barriers other than MRC fencelines to test their practicality for marking-movement studies.

M-99 should be the drug of choice when immobilizing animals not to be consumed. An effort should be made to clear treated animals for consumption so the drug may be used on hunted populations.

Radio-tracking collars should be tested on unenclosed moose.

PUBLICATIONS

Aerial census data will be prepared for both scientific and popular publication.

Table 29. Moose seen within four one-square-mile enclosures by 8 observers during 312 hours present within the enclosures. Kenai Moose Research Center: April 1970. (46 moose were enclosed at the time) "I" was mock-hunting moose only in likely places and saw 13 of the 15 moose along fencelines.

	OBSERVER NO.									
	A	B	C	D	E	F	G	H	Total	I
Hours	49	58	17	63	55	37	21	12	312	22
Moose Seen	6	4	0	5	3	2	1	0	21	15
Hrs/ Moose	8.2	14.5	-	12.6	18.3	18.5	21	-	14.9	1.47

Results of all immobilizations of moose by Alaska Department of Fish and Game will be incorporated into a review of techniques for immobilizing moose. Trap design will be included in a general paper on the Moose Research Center.

LITERATURE CITED

Bennett, L.J. *et al*. 1940. A study of deer populations by use of pellet-group counts. J. Wildl. Mgmt. 4:398-403.

Bishop, R. H. 1969. Moose report. Annual Project Segment Report. Vol. X. W-15-R-3. Work plan K. 152 p.

Evans, C.D.; Troyer, W.A. & C.J. Lensink. 1966. Aerial census of moose by quadrat sampling units. J. Wildl. Mgmt. 30:767-776.

Harthorn, A.M. 1965. Application of pharmacological & physiological priciples in restraint of wild animals. Wildl. Monographs 14:78 p.

Houston, D.B. 1969. Immobilization of the Shiras moose. J. Wildl. Mgmt. 33:534-537.

Neff, D. J. 1968. The pellet-group technique for big game trend, census & distribution: a review. J. Wildl. Mgmt. 32:597-614.

Rasmussen, D. I. & E. R. Dorman. 1943. Census methods & their application in the management of mule deer. Trans. N. Am. Wildl. Conf. 8:369-379.

Rausch, R. A. & R. H. Bishop. 1968. Report on 1966-67 moose studies. Annual Project Segment Report. Vol. VIII & VIX. W-15-R 2-3. Work Plan K. 263 p.

Rausch, R. A. & A. E. Bratlie. 1965. Assessments of moose calf production & mortality in Southcentral Alaska. Ann. Conf. W. Assoc. State Game & Fish Comm. 45:11p.

Slater, L. 1963. (ed.) Bio telemetry. Pergamon, London. 369 p.

Siniff, D. B. and R. O. Skoog. 1964. Aerial censusing of caribou using random stratified sampling. J. Wildl. Mgmt. 28: 391-401.

Taber, R. D., & Cowan I. McT. 1969. Capturing & marking wild animals. In: Wildlife Management Techniques. ed: Giles, R. The Wildlife Society. p 277-317.

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