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# INTERIOR MOOSE
# AND MOOSE DISEASE STUDIES

by
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Volume III
Project Progress Report
Federal Aid in Wildlife Restoration
Projects W-17-7 and W-17-8, Job 1.11R and
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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: John W. Coady

Project No.: W-17-7 and W-17-8 Project Title: Big Game Investigations

Job No.: 1.11R Job Title: Seasonal Movement and Distribution of Moose Breeding in the Alaska Range Foothills

Period Covered: July 1, 1974 through June 30, 1976

## SUMMARY


Twenty-three adult moose were radio-collared in fall 1973 and 18 adult moose were radio-collared in fall 1974. Eight moose marked in 1974 were originally collared in 1973. A total of 861 radio locations of these moose were made.

Shooting and wolf predation were the two greatest mortality factors affecting moose marked during this study. Nine percent (2) of the moose collared in 1973 were killed by hunters, while 17 percent (4) and 13 percent (2) of the moose collared in 1973 and 1974, respectively, and monitored for one year appeared to have been killed by wolves. Three of four cows killed by wolves had lost calves to probable wolf predation shortly before their own demise. Calf mortality on the Tanana Flats between 1973-75 is estimated at 85 percent by 2 to 3 months of age and 91 percent by 1 year of age. Time required to sight radio-collared moose after radio location suggests that habitat selection and group size are two major factors affecting visibility of moose from an aircraft. Time required to sight collared moose in closed canopy habitats was two to four times greater than that for animals in open canopy habitats. Cows with calves occurred in the smallest groups during fall and required the longest time to locate, while lone cows and bulls occurred in larger groups during fall and required less time to locate. Visibility biases associated with differential habitat selection and group sizes of lone cows, cows with calves and bulls may decrease the accuracy and precision of aerial surveys.

Seasonal movement patterns included short and long distance movements, both between the mountains and the flats and totally within the mountains. One hundred percent loyality to seasonal home ranges observed for 10 moose during a two-year period suggests that moose are extremely traditional in their seasonal movement patterns.

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## BACKGROUND

Moose (*Alces alces*) are Holarctic in distribution (Rausch 1963), occurring in several Eurasian countries, Canada, the conterminous United States and Alaska. Three Eurasian races and four North American races of moose are recognized (Peterson 1974). The Alaskan moose (*A. a. gigas*) is of pre-Wisconsin age, remains having been found in Illinoian beds in the "Cripple Creek sump" near Fairbanks (Péwé and Hopkins 1967).

Moose are Alaskan residents of long standing, having immigrated to the state over 175,000 years ago (LeResche et al. 1974). Interior Alaska was largely a treeless grassland or tundra at that time and moose probably existed in very low numbers during the early colonizing years. Subsequent climatic warming trends resulted in a vegetation complex of trees, shrubs and grasslands similar to that in Interior Alaska today. This change of habitat was favorable for moose and they increased and became firmly established in the state.

Since their arrival in Alaska, moose, like all species, have fluctuated in numbers. The status of moose populations during the early 20th century is uncertain. However, historical records and comments by early hunters and trappers suggest that moose existed in at least low to moderate numbers throughout most of Interior Alaska. In the late 1940's, 1950's and early 1960's moose gradually increased in abundance, reaching a maximum around 1965 (Fig. 1). Since that time moose numbers have generally declined to the present low levels.

The increase of moose populations during the 1940's and 1950's was due to a combination of events. The most important factor was probably a large increase in moose habitat caused by a high number of natural and man-caused fires, and developments such as homesteading, mining and construction (Bishop and Rausch 1974). Regrowth of shrubs important in the diet of moose in these disturbed areas greatly expanded their food supply. Moose on a high quality diet frequently have high reproductive success, and during the years between 1956 and 1964, the ratio of calves per 100 cows during fall in Game Management Unit 20A, for example, was high, ranging from 42 to 55.

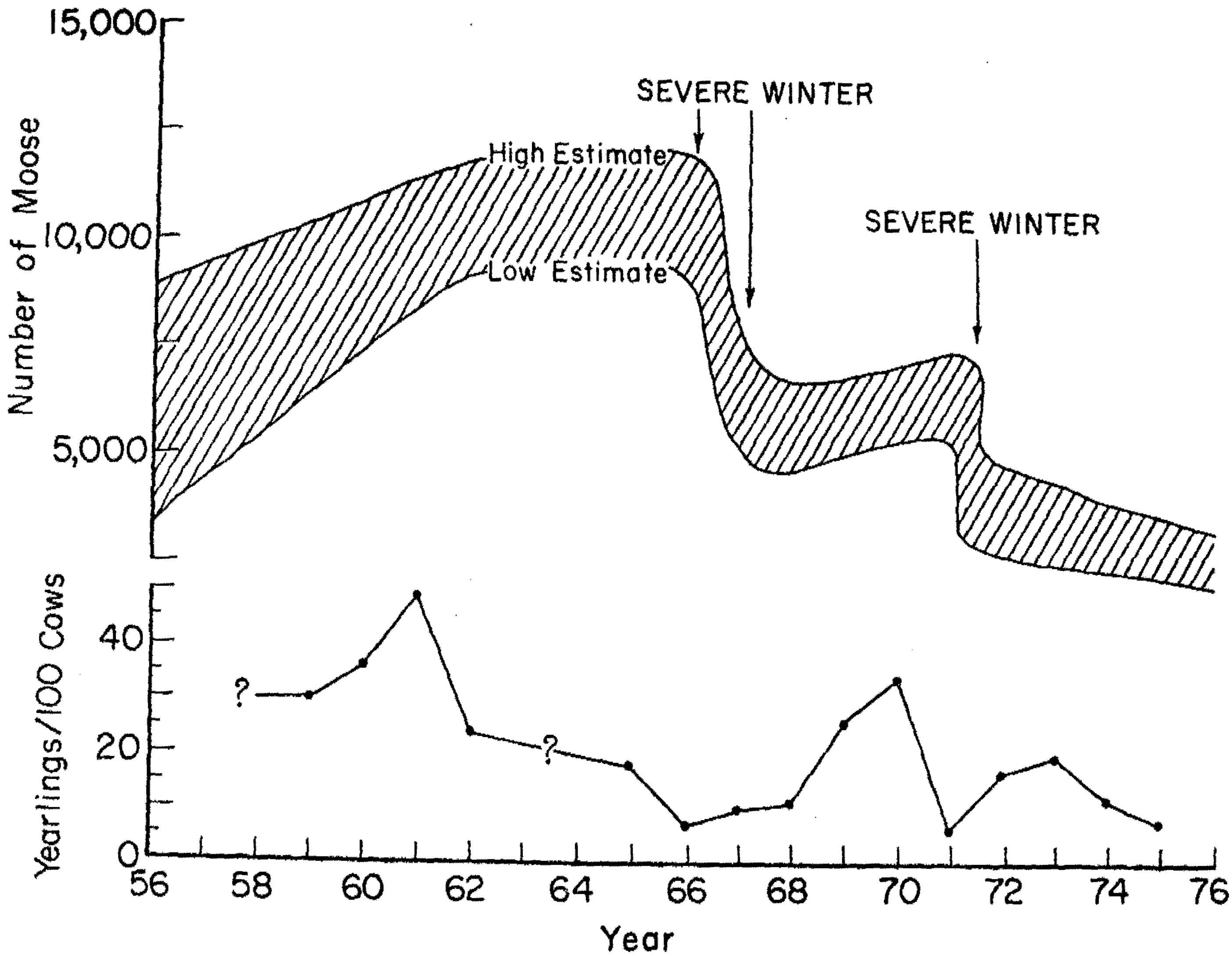



Fig. 1 Estimated moose abundance and yearlings per 100 cows in Unit 20-A moose populations. Severe winters caused sharp declines in moose populations. Note that periods of population growth are characterized by relatively high yearling survival, while periods of population decline correspond to low yearling survival.

Two other factors contributed to population growth from late 1940 to early 1960. Predator control was practiced during this time (Bishop and Rausch 1974). Poisons were used until approximately statehood in 1959, and aerial hunting and bounties on wolves (*Canis lupus*) continued throughout the period. The net effect of this program was to reduce wolf populations and minimize wolf predation on moose. Secondly, relatively mild winters during this interval contributed to high overwinter survival of calves and adults during most years (Bishop and Rausch 1974).

While moose populations throughout most of Interior Alaska continued to increase during the late 1940's and 1950's, these rapid increases probably slowed and eventually stabilized during the early 1960's. Moose were then extremely abundant and an estimated 10,000 to 12,000 animals existed in Unit 20A alone. It appears that moose numbers had approached, and eventually exceeded, a critical balance with their food supply during the 1960's. Inadequate food supply often leads to reduced reproductive success, and the observed ratio of calves per 100 cows in Unit 20A during fall 1965 was one-half of that occurring during several previous years.

The winter of 1965-66 was probably the turning point for moose populations throughout much of Interior Alaska. There were too many moose for the available food supply, and this problem was aggravated by two successive severe winters (Fig. 1). Three feet of snow accumulated by December 1965 in moose winter habitats, and snow depths continued to increase throughout the winter. Snow depths during the winter of 1966-67 were also greater than usual. Overwinter calf survival during these years was very poor, and only 7 yearlings per 100 cows in Unit 20A were found by spring 1966, and 10 yearlings per 100 cows by spring 1967 (Fig. 1). Furthermore, it appears that adult mortality during these winters was also high. Perhaps 50 percent of the moose population in Unit 20A and adjacent areas died during the winter of 1965-66 alone.

Although their long legs usually allow moose easy movement in deep snow, even they can be inadequate during severe winters. Snow depths in excess of two and one-half to three feet force moose to "plow" or "bound" through the snow (Coady 1974). When the energy required to move in this manner is considerably greater than the energy moose can obtain from their food, malnutrition and eventual death may occur. Calves are even more affected by deep snow than adults because of their shorter legs, and lower fat reserves.

Winters were relatively mild between 1967 and 1970, and the moose populations in Unit 20A and adjacent areas probably remained stable or perhaps even began to increase. Calf survival through summer to fall sharply increased during this period, and yearling overwinter survival more than tripled between 1967 and 1970.

However, during the winter of 1970-71 disaster again struck the moose populations in Interior Alaska (Fig. 1). Snow conditions during that winter were as severe as those during the 1965-66 winter, and again the winter mortality of moose apparently approached 50 percent. In spring 1971 a record low of 6 yearlings per 100 cows was seen in Unit 20A, indicating that virtually all calves had died during the winter. Following the 1970-71 winter the moose populations in Unit 20A and adjacent areas did not stabilize or increase, but instead continued to decline.

The reasons for the steady decline of moose populations since 1971 are clear: a continuous and unavoidable mortality among adults, and a low recruitment of new animals, or yearlings, into the breeding adult population. However, the factors causing these circumstances are less clear. Hunting is one obvious source of adult mortality in many areas of Interior Alaska. For example, reported hunter harvest in Unit 20A prior to 1970, when moose were relatively abundant, ranged between 145 and 258 animals per year. Thereafter, the reported harvest increased from 298 in 1970 to 710 in 1973. In 1974 and 1975 the hunting season was sharply reduced, and the harvests were 341 and 30, respectively. Thus, hunting during 1970 through 1974 was certainly a mortality factor which contributed to the eventual decrease in total moose numbers in Unit 20A.

Although hunting may have been a significant cause of mortality in certain heavily hunted areas, it was probably not a major factor contributing to the widespread and generally synchronized decline of moose throughout Interior Alaska. Moose populations in lightly hunted and even unhunted regions have experienced similar population declines. While large areas of the Chena River and Beaver Creek drainages are very lightly hunted, they too have low numbers of calves and yearlings, and have experienced sharp population declines in recent years. Further, in spite of an extremely low hunter harvest in Unit 20A during 1975, the moose population has continued to decline in that area. Moose in unhunted populations in McKinley Park are also apparently experiencing similar declines. Several individuals familiar with Park wildlife have reported a continuous reduction in moose abundance during the past several years. An aerial survey conducted by Park personnel during fall 1974 revealed low calf and yearling ratios comparable to those seen in Unit 20A.

Poor range conditions have probably not been a major factor contributing to moose declines in recent years in Interior Alaska. Although quantity and quality of moose range are probably lower today than during the 1950's and 1960's, ranges appear to be capable of supporting considerably more moose than the present level. A study (Job 1.3R) of Unit 20A moose habitat and browse use conducted by the Alaska Department of Fish and Game (Cushwa and Coady 1976, Coady and Simpson in prep.) concluded that neither food nor habitat were limiting moose numbers. Further, rate of growth and maximum body size of moose in Unit 20A are among the highest in the state (Coady 1973) both of which are characteristic of animals on a high quality diet.

The influence of disease on moose mortality has not been closely examined. However, observations from Alaska and western Canada suggest that disease is probably not a significant mortality factor among either calves or adults in these areas.

With the exception of severe winters, predation may well have been the most significant and widespread cause of moose mortality during the past several years. Predator control during the 1950's probably facilitated the large increase in moose numbers during that period. With a decrease in the intensity of predator control beginning about 1959, wolves probably responded to the abundant moose populations by increasing. Even as moose populations began to decline in 1966, there were still adequate numbers of prey to support high predator populations. Further, wolves may have compensated for declining moose populations by heavily utilizing snowshoe hares (*Lepus americanus*), which peaked during the late 1960's and early 1970's. When hares declined in 1972 or 1973, abundant wolf populations were again forced to rely primarily on declining moose populations for food. Therefore, throughout much of Interior Alaska at this time we are faced with high wolf populations. Biologists estimated from aerial surveys in 1975 that approximately 200 wolves and 3000 moose are present in Unit 20A during most of the year. This ratio of approximately 1 wolf to 15 moose is considerably higher than moose populations can support, and is probably the major factor in many areas which has resulted in the declining moose populations in recent years. An imbalance between wolves and moose also may be causing low calf survival and declining moose populations observed in many other areas of Interior Alaska as well.

The eventual recovery of moose populations in Interior Alaska is assured. Nevertheless, the prospects for a significant increase in moose abundance and improved hunting in the near future are not good. Although wolf populations in Unit 20A may be declining, they will continue to further depress moose populations until a normal balance between predator and prey is restored and moose can begin to increase. This process will no doubt take several years, depending upon the rate of wolf population declines, severity of winters, etc. If wolf numbers are reduced by control programs in selected areas, the recovery rate of moose populations should be increased. However, this recovery will still require several years. Meanwhile moose hunting will be sharply restricted to assure that it does not further depress populations.

Moose population fluctuations will continue in the future in response to ecological and management changes. Certain factors influencing moose abundance, such as winter weather, cannot be controlled. However, other factors can be influenced, and an awareness of these factors can help us avoid the extreme population fluctuations that have occurred during the past 10 years. As management of land in Alaska becomes more intense, it is unlikely that fires or development will create vast areas of new moose habitat resulting in extensive population growth as occurred during the late 1940's and 1950's. Moose populations will be more closely managed by liberalizing or restricting seasons and bag limits in response to population trends and publicly accepted management goals and it may be necessary to control wolf populations when their numbers become excessive.

Since statehood in 1959 the Alaska Department of Fish and Game has actively engaged in collecting information in Interior Alaska relating to moose biology. Major emphasis has been placed on extensive aerial surveys during fall to document changes in productivity, to assess the effect of hunting on bull-cow ratios, to determine survival of moose to 1.5 years of age, and to document changes in relative abundance and distribution of moose. Annual aerial surveys have been conducted in selected areas during spring to assess survival of moose to 1 year of age, and to monitor changes in relative abundance and distribution of moose. Harvest statistics and basic life history information have also been collected. In spring 1966 a moose calf tagging program was initiated on the Tanana Flats south of Fairbanks to help determine distribution, movement and population identity of moose calving in the area. Between 1966 and 1969 over 800 moose calves were tagged, and locations of tagged moose continue to be recorded as sightings are made.

Major contributions to moose studies in Interior Alaska have been made by Robert A. Rausch (Rausch 1967, 1971; Rausch and Bishop 1968) and Richard Bishop (Bishop 1969, 1970; Bishop and Rausch 1974). Together these individuals conducted and directed many early studies of moose in Interior Alaska. Their work has provided the background for and continues to provide guidance in developing current moose studies.

In February 1971, during a winter of record snowfall in Interior Alaska, a moose research program was initiated at Fairbanks to further identify and quantify major control factors affecting moose populations. Basic emphasis of the program centered on effects of snow and range conditions on the production, survival and distribution of moose in Interior Alaska. Information obtained from this and subsequent projects will hopefully contribute to efficient management of moose in Interior Alaska, where growth of human populations and demands on wildlife and land resources are rapidly increasing.

## OBJECTIVES

The objective of this study is to determine population identities and seasonal movement patterns of major Alaskan moose herds. Objectives specific to this job are: to document major mortality factors of moose in Unit 20A; to determine the influence of weather and habitat on seasonal distribution of moose breeding in the northern foothills of the Alaska Range; to determine the annual loyality of individual moose to movement patterns and seasonal home ranges; and to determine the influence of habitat, group size and composition and activity on visibility of moose from aircraft.

## STUDY AREA

The study area includes the northern foothills and mountains of the central Alaska Range and the Tanana Flats. This includes a 3000km$^2$ region of rugged, mountainous terrain drained by the Wood and Little Delta Rivers and Dry Creek, and an adjoining 4800km$^2$ alluvial lowland lying south and west of the Tanana River. The mountainous region within the study area is part of the Alaska-Aleutian physiographic province

(Wahrhaftig 1965). The region consists of a series of braided glacial streams, glacier-carved ridges and high peaks. Mountains rapidly merge into the Tanana Flats lowland of the Western Alaska physiographic province (Wahrhaftig 1965). Surface deposits from glacial streams flowing into the Tanana Flats on the south form a broad belt of coalescing fans that grade from coarse sand and gravel near the mountains to fine sand and silt at lower elevations. Except for scattered low hills, the flats are an area of little relief. The entire region is underlain by permafrost (Black 1958, Wahrhaftig 1965), and drainage is poor, resulting in numerous small, shallow ponds, extensive bogs and meander scars.

Vegetation and moose habitats in Interior Alaskan mountains and lowlands have been described by LeResche et al. (1974) and Coady and Simpson (in prep.). Five major vegetative types were identified: herbaceous bog, heath, tall shrub, deciduous tree and coniferous tree. Herbaceous bogs occur primarily in the northern portion of the Tanana Flats, and cover approximately 7 percent of the area. Vegetation is dominated by emergent species, and live trees and shrubs are totally absent (Table 1). Stagnant or slowly flowing water depths vary seasonally, ranging from several centimeters late in the summer to several meters after spring run-off. Bog bottoms consist of a meter or more of dead and decaying vegetation, and permafrost depths are presumably well below the upper surface of organic material. Isolated areas of herbaceous bogs occur in mountain stream valleys and along lake margins below 1200 m elevation. However, the area covered by this vegetation type in the mountainous portion of the study area is very small.

Heath communities occupy approximately 40 percent of both the Tanana Flats and the mountains below 1200 m elevation. Dominant vegetation consists of mosses and shrubs, although scattered trees and various herbs rooting on sedge hummocks are common (Table 1). Both mineral soil and permafrost tables occur within a meter of the surface, although seasonal thaw may extend to greater depths in some areas. Soil moisture is generally high and shallow standing water is common, particularly on the flats.

Tall shrub communities occur over approximately 10 percent of the Tanana Flats, and a somewhat larger portion of the mountains. This habitat is common along streams, sloughs, and margins of ponds and meander scars in lowlands, and along streams and on well-drained south facing slopes at lower elevations in the mountains. Vegetation ranges from pure to mixed stands of willow and alder with a dense understory of mosses, herbs and low shrubs in poorly drained sites (Table 1). Exposed mineral soil, low moisture content, and absence of permafrost are common on recent alluvial deposits, while a thick organic layer, impeded drainage, and high permafrost tables are found in other areas.

Discontinuous pure or mixed stands of deciduous tree species occur over less than 10 percent of the flats and mountains. These stands are most common on elevated areas of the flats and on coarse river alluvium in the flats and mountains. Understory vegetation ranges from a dense herbaceous cover in cottonwood (*Populus balsamifera*) stands to mixed

Table 1. Dominant plant species in five vegetation types in the Tanana Flats and Central Alaska Range, Alaska.

| Type | Dominant species: Trees | Tall shrubs | Low shrubs | Herbs |
|---|---|---|---|---|
| Herbaceous Bog | None | None | None | *Gramineae*<br>*Carex* spp.<br>*Equisetum* spp.<br>*Eriophorum* spp<br>*Potentilla palustris* |
| Heath Bog | *Picea mariana*<br>*Larix laricina*<br>*Betula papyrifera* | *Salix bebbiana*<br>*Salix planifolia*<br>*Salix arbusculoides*<br>*Betula papyrifera x glandulosa* | *Betula nana*<br>*Salix myrtillifolia*<br>*Salix brachyocarpa*<br>*Ledum palustre*<br>*Vaccinium uliginosum* | *Gramineae*<br>*Eriophorum* spp.<br>*Equisetum* spp.<br>*Potentilla palustris*<br>*Pyrola* spp. |
| Tall Shrub | *Populus balsamifera*<br>*Betula papyrifera*<br>*Picea mariana*<br>*Picea glauca* | *Salix bebbiana*<br>*Salix monticola*<br>*Salix arbusculoides*<br>*Alnus incana*<br>*Alnus crispa* | *Rosa acicularis*<br>*Potentilla fruticosa*<br>*Ledum palustre*<br>*Vaccinium uliginosum*<br>*Viburnum edule* | *Equisetum* spp.<br>*Gramineae*<br>*Epilobium angustifolium*<br>*Pyrola* spp.<br>*Cornus canadensis* |
| Deciduous | *Betula papyrifera*<br>*Populus tremuloides*<br>*Populus balsamifera* | *Alnus crispa*<br>*Alnus incana*<br>*Salix alaxensis*<br>*Salix novae-angliae* | *Rosa acicularis*<br>*Viburnum edule*<br>*Ribes triste*<br>*Ribes hudsonianum* | *Equisetum* spp.<br>*Gramineae*<br>*Epilobium angustifolium*<br>*Pyrola secunda*<br>*Trientalis europea* |
| Coniferous | *Picea glauca*<br>*Picea mariana*<br>*Larix laricina* | *Alnus crispa*<br>*Alnus incana*<br>*Salix alaxensis*<br>*Salix bebbiana*<br>*Salix arbusculoides* | *Rosa acicularis*<br>*Vaccinium vitis-idaea*<br>*Linnaea borealis*<br>*Arctostaphylos uva-ursi*<br>*Ribes* spp. | *Equisetum* spp.<br>*Cornus canadensis*<br>*Pyrola* spp.<br>*Trientalis europea*<br>*Mertensia paniculata* |

herbs and low shrubs in aspen (*Populus tremuloides*) and birch (*Betula papyrifera*) stands. Scattered willows and alders are common among cottonwood communities (Table 1). Well-drained mineral soil lies close to the surface and permafrost tables are deep or nonexistent.

Extensive low, dense black spruce (*Picea mariana*) and tamarack (*Larix laricina*) forests and scattered black and white spruce (*Picea glauca*) stands cover approximately one-third of the flats and mountains. Mature white spruce forests with a ground cover of low shrubs and mosses are common on elevated areas near streams in the flats, and near streams and on well-drained slopes in the mountains. Black spruce forests underlain by a dense mat of moss, herbs and low shrubs grow in poorly drained areas (Table 1). Soil organic layer, moisture content and permafrost tables range from low in young white spruce stands to high in black spruce and tamarack stands.

Moose were radio-collared in the vicinity of Snow Mountain Gulch and Gold King Creek. Snow Mountain Gulch is located 90 km south of Fairbanks. The area forms a gentle bowl in the foothills of the Alaska Range and ranges in elevation from 600-1200 m. Conifer and tall shrub stands at lower elevations merge into treeless low shrub communities and herbaceous meadows in higher areas. Gold King Creek flows north from the Alaska Range, approximately 100 km south of Fairbanks. The creek flows through a relatively narrow, steep-sided valley in the mountains, ranging in elevation from 600 to 1200 m. Vegetation in the valley bottom is dominated by conifers, while that on the valley sides consists largely of stands of low and tall shrubs.

## METHODS

Standard helicopter darting techniques were used to capture moose. Succinylcholine chloride (Anectine) was used as an immobilizing agent, and Palmer Company Cap-Chur guns and 3 cc darts were used to shoot animals. Each immobilized moose was radio-collared and color-coded with ear streamers attached with numbered ear tags. Standard body measurements, an incisor tooth for aging, a hair sample for mineral analysis and a blood sample for hemotology, physiological chemistry and serology analyses were obtained.

Radio collars were designed and constructed by Oceans Applied Research Corporation (OAR), San Diego, California. These units, weighing 8.8 kg, transmitted a pulsed cw signal (1 pulse per 2-2.5 seconds) on frequencies between 150.800 to 151.075 MHz. Signal detection range was approximately 160 km ground to air, and life expectancy of the unit's lithium battery was one or more years. However, operational life of the units usually ranged from 8 to 11 months. A LA-12 telemetry receiver constructed by AVM Instrument Company, Champaign, Illinois, and a three-element yagi antenna, constructed by Hi-Gain Electronics Corporation, Lincoln, Nebraska were used.

A PA-18-150 with one antenna mounted facing forward on the struts was the most satisfactory aircraft to locate moose. However a Helio-Courier, a C-180 and a C-185 were also used with good success. Both the pilot and observer wore earphones, and the plane (and antenna) was flown in the direction of loudest signal reception until the transmitter and moose were located. Location of each animal was plotted on 1:63,360 USGS maps or on vegetation type maps constructed by ADF&G (Job 1.3R). Search time required to visually sight a moose after it was radio-located was recorded, and used as a measure of the relative visibility of the animal from an aircraft. Time of day, habitat (herbaceous bog, heath, tall shrub, deciduous tree, coniferous tree), activity (bedded, standing, moving, feeding), association with other moose and ambient temperature were also recorded.

## FINDINGS AND DISCUSSION

### Immobilization and Location

In 1973 average time from darting to immobilization was 12.8 minutes (range 7-19 minutes), and average down time was 29.8 minutes (range 8-44 minutes). In 1974 average time from darting to immobilization was 11.2 (range 6-27 minutes), and average down time was 27.6 minutes (range 3-46 minutes). Seventy-nine percent and 69 percent of all moose darted were immobilized in 1973 and 1974, respectively. Anectine doses of 27, 26 and 21 mg were used on lone cows, cows with calves, and bulls, respectively, in 1973, while doses of 29, 28 and 23 mg were used for the same groups in 1974. Anectine doses required for successful immobilization decreased sharply during late fall and early winter. For example, 27 mg were required to immoblize lone cows in early October 1973. However, the dose declined to 24 mg in early November, to 22 mg in late November, and to 21 mg in mid-December. A similar decline in dose requirements was observed in 1974.

Results of this study are based on 861 locations of radio-collared moose. An attempt was made to locate moose at weekly intervals. However, the frequency of locating some animals occasionally declined to once every two to three weeks during particularly cold weather.

### Adult and Calf Mortality

Twenty-three adult moose were radio-collared between October 8 and December 11, 1973, and 18 adult moose were radio-collared between October 11 and October 25, 1974 (Table 2). Eight moose marked in 1974 were originally collared in 1973. One moose was killed by an overdose of Anectine and one charged and was shot in 1973, and no animals were killed in 1974.

Shooting and wolf predation are two known factors contributing to high adult mortality (Table 2). Nine percent (Nos. 2 and 15) of the moose collared in 1973 were killed by hunters, although no animals collared in 1974 were known to have been shot. Seventeen percent (Nos. 4, 9, 14 and 18) of the 23 adults radio-collared in 1973 were proven or are highly suspected of having been killed by wolves during 1973-74. A fifth animal (No. 5) disappeared in an area and at a time of numerous

Table 2. History of moose radio-collared in 1973 and 1974.

| Radio No. | Acc. No. | |
|---|---|---|
| 1 | 93449 | Last seen 7/75 when radio stopped; calved in 1974 and 1975. |
| 2 | 93466 | Shot by hunters. |
| 2 | 93694 | Last seen 5/75 when radio stopped. |
| 3 | 93450 | Last seen 1/16/74; probably dead. |
| 4 | 93468 | Killed by wolves 5/6/74; twin calves disappear; radio retrieved. |
| 5 | 93451 | Last seen 2/14/74 when radio stopped; calf disappeared 12/13/73; both may have been killed by wolves. |
| 6 | 93465 | Last seen 10/74 when radio stopped; calved in 1974. |
| 7 | 93462 | Last seen 7/1/75 when radio stopped. |
| 8 | 93452 | Last seen 7/25/74 when radio stopped; later seen 11/13/74. |
| 9 | 93457 | Killed by wolves 1/21/74; calf killed by wolves 1/15/74; radio retrieved. |
| 10 | 93461 | Last seen 7/1/75 when radio stopped; calved in 1974 and 1975. |
| 11 | 93529 | Last seen 9/18/74 when radio stopped; probably dead. |
| 12 | 93453 | Last seen 5/21/75 when radio stopped; calved in 1974. |
| 13 | 93467 | Last seen 6/7/74 when radio stopped; calved in 1974; probably dead. |
| 14 | 93455 | Killed by wolves 10/24/73; radio retrieved. |
| 14 | 93594 | Last seen 6/7/74 when radio stopped; calved in 1974. |
| 15 | 93527 | Shot by hunters |
| 15 | 93697 | Killed by wolves 2/18/75 |
| 16 | 93456 | Last seen 6/7/74 when radio stopped; later seen 10/28/74. |

Table 2. History of moose radio-collared cont.

| Radio No. | Acc. No. | |
|---|---|---|
| 17 | 93528 | Last seen 8/2/74 when radio stopped. |
| 18 | 93460 | Killed by wolves 4/18/74; calf probably killed by wolves 3/7/74; radio retrived. |
| 19 | 93458 | Last seen 8/2/74 when radio stopped; probably dead. |
| 20 | 93463 | Killed by wolves 5/7/75; retrieved radio. |
| 23 | 93898 | Last seen 8/25/75 when radio stopped; calved in 1975. |
| 24 | 93902 | Radio failed 11/21/74; last seen 1/16/75. |
| 25 | 93904 | Radio failed immediately; last seen 7/2/75. |
| 26 | 93905 | Last seen 5/6/75 when radio stopped. |
| 27 | 93907 | Last seen 5/7/75 when radio stopped. |
| 28 | 93908 | Last seen 7/17/75 when radio stopped; produced twins in 1975 and 1 disappeared 6/10/75. |
| 29 | 93909 | Last seen 7/2/75 when radio stopped. |
| 30 | 93910 | Last seen 6/25/75 when radio stopped; calved in 1975. |
| 31 | 93911 | Last seen 8/25/75 when radio stopped. |
| 32 | 93912 | Last seen 7/25/75 when radio stopped; calved in 1975. |

wolf sightings, and is suspected of having been killed by wolves. Thirteen percent (Nos. 15 and 20) of the 16 adults collared in 1974 and monitored throughout the winter of 1974-75 appeared to have been killed by wolves. Radios on the two additional animals collared in 1974 failed shortly after installation, and are not included in this analysis. All cases of suspected wolf predation were located because the transmitter continued to function after the moose was dead. Unfortunately, electrical wires connecting the battery on the bottom of the collar to the transmitter on the top were not adequately protected, and therefore some cases of radio failure and subsequent inability to locate moose may have been caused by wolves killing moose and severing electrical leads before the carcass could be radio-located. Therefore, predation rates reported here certainly represent minimum values.

Both sexes and all age groups of radio-collared moose were susceptible to wolf predation (Table 3). Nevertheless, cows with calves were preyed upon to a greater extent than expected from their occurrence in the sample. Further, predation occurred at more or less regular intervals between October and May.

Wolf predation on cows may be closely related to that on their calves. Causes of calf mortality were difficult to determine because calves were not radio-collared, and only one calf was a confirmed wolf kill. However, four calves disappeared from radio-collared dams during winter periods in areas of heavy wolf activity. In three of the four cases, the dam succumbed to wolf predation within one to eight weeks after the calf disappeared. Therefore, the probability of a cow being killed by wolves subsequent to her calf meeting a similar fate may be high. Similarly, if a cow is first killed by wolves, predation on her calf seems likely (e.g. Radio No. 4, Table 2). While not statistically significant, these limited data suggest that not only calves but also cows with calves may be more susceptible to wolf predation than other moose.

While causes of calf mortality are difficult to document, the rate of mortality is clear. A survivorship curve for 21 calves of radio-collared cows suggests that summer mortality is extremely high (Fig. 2). Calf mortality was approximately 85 percent by 2 to 3 months of age, and 91 percent by 11 to 12 months of age. Pregnancy rates of radio-collared cows based on sightings of newborn calves were 64 percent. However, pregnancy rates of 82 percent (Coady 1973) and 85 percent (Gasaway, pers. comm.) were observed for adult cows on the Tanana Flats in 1971 and 1975, respectively. Therefore, this curve is probably a maximum estimate of survivorship, since additional calves were probably born but died before being observed. Further evidence for high calf mortality in recent years on the Tanana Flats and adjacent Alaska Range has been provided by aerial surveys during spring to determine yearlings per 100 cows (Fig. 1), and by observations of collared cows known to be pregnant during early May (Gasaway, pers. comm.). Extremely high calf mortality observed in this study is clearly a major factor preventing population growth.

Table 3. Sex, age and date of death of wolf-killed radio-collared moose between 1973-1975.

| Radio No. | Sex | Age | Date of Death |
|---|---|---|---|
| 14 | F | - | 10/24/73 |
| 9 | F/c | 9 | 1/21/74 |
| 5 | F/c | 17 | 2/14/74 (suspected wolf-kill; carcass not located. |
| 15 | F | 6 | 2/18/75 |
| 18 | F/c | 12 | 4/18/74 |
| 4 | F/2c | 11 | 5/6/74 |
| 20 | M | 5 | 5/7/75 |

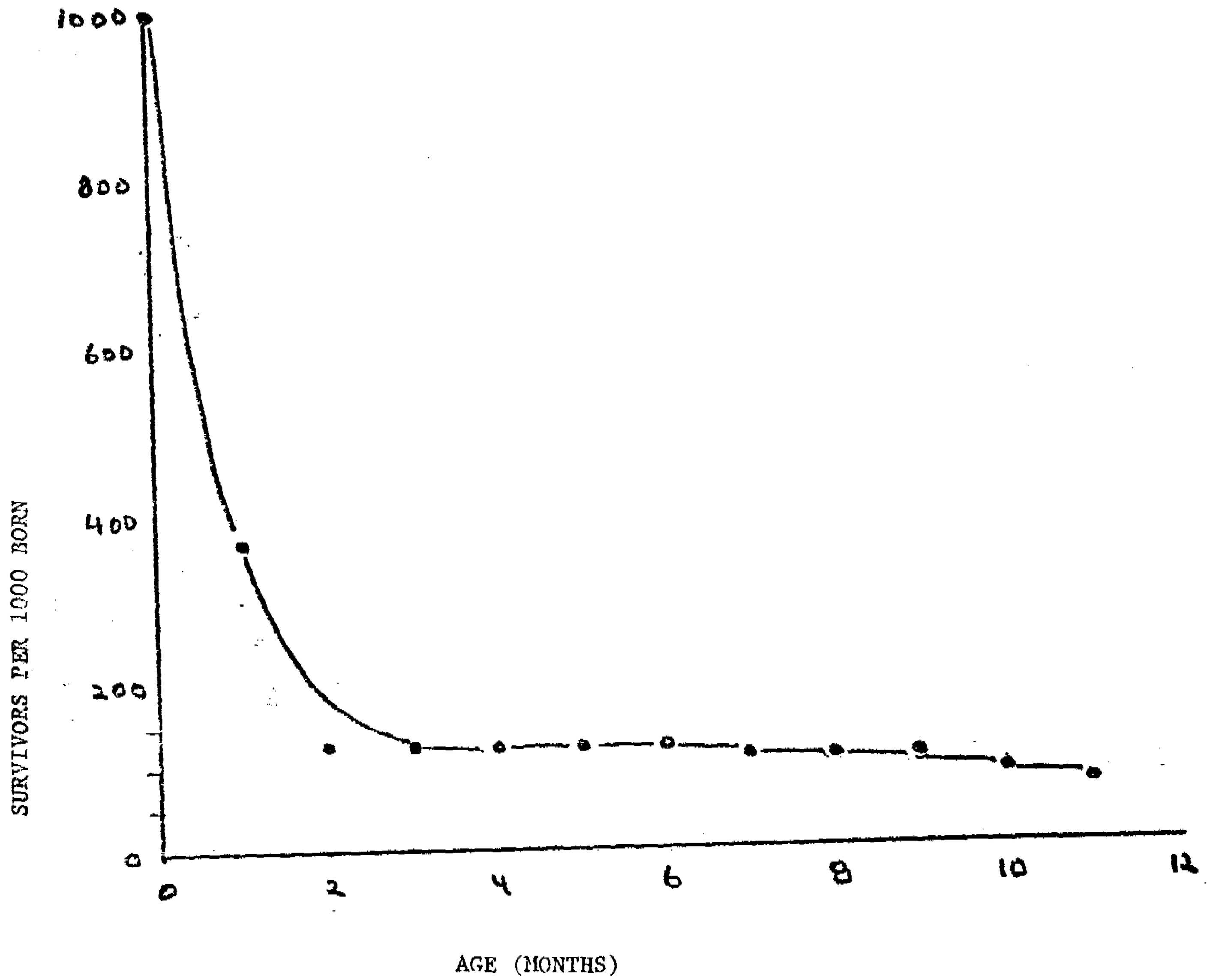



Fig. 2 Survivorship curve for calves of radio-collared moose cows between 1973-1975. Sample size was 21.

Fig. 3 Percent of total habitat use by radio-collared lone moose cows between 1973-1975.

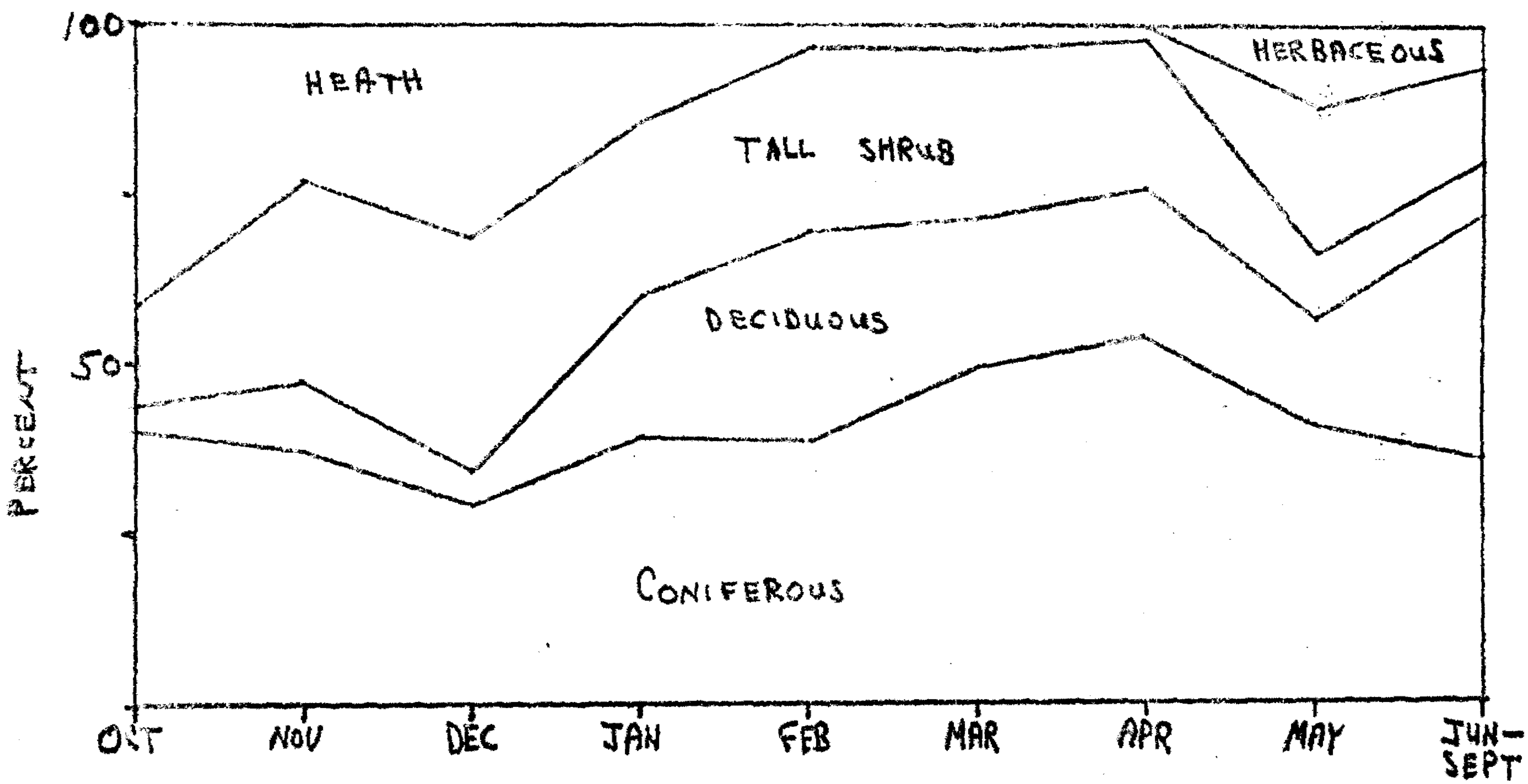


Fig. 4 Percent of total habitat use by radio-collared moose cows with calves between 1973-1975.

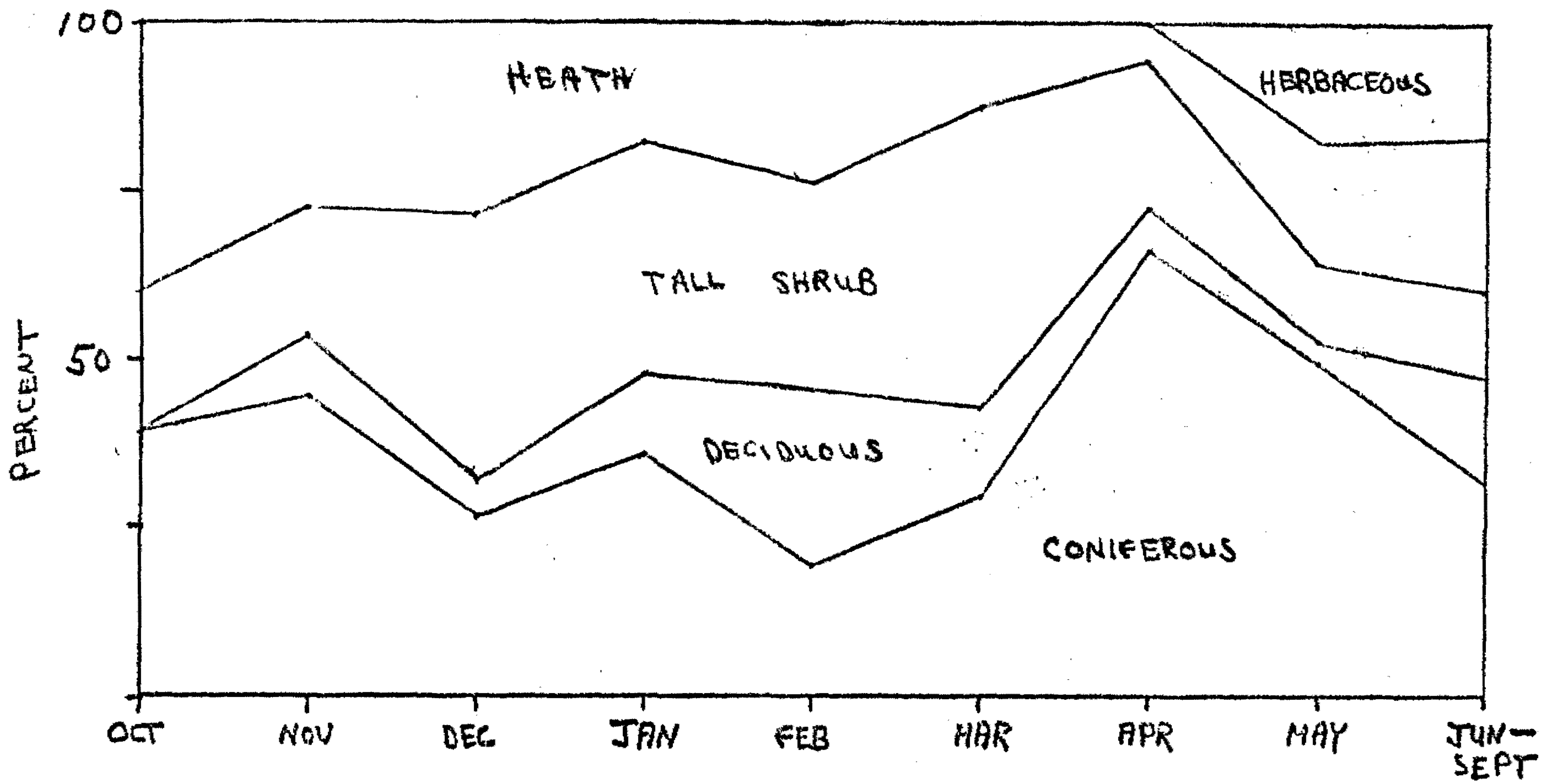
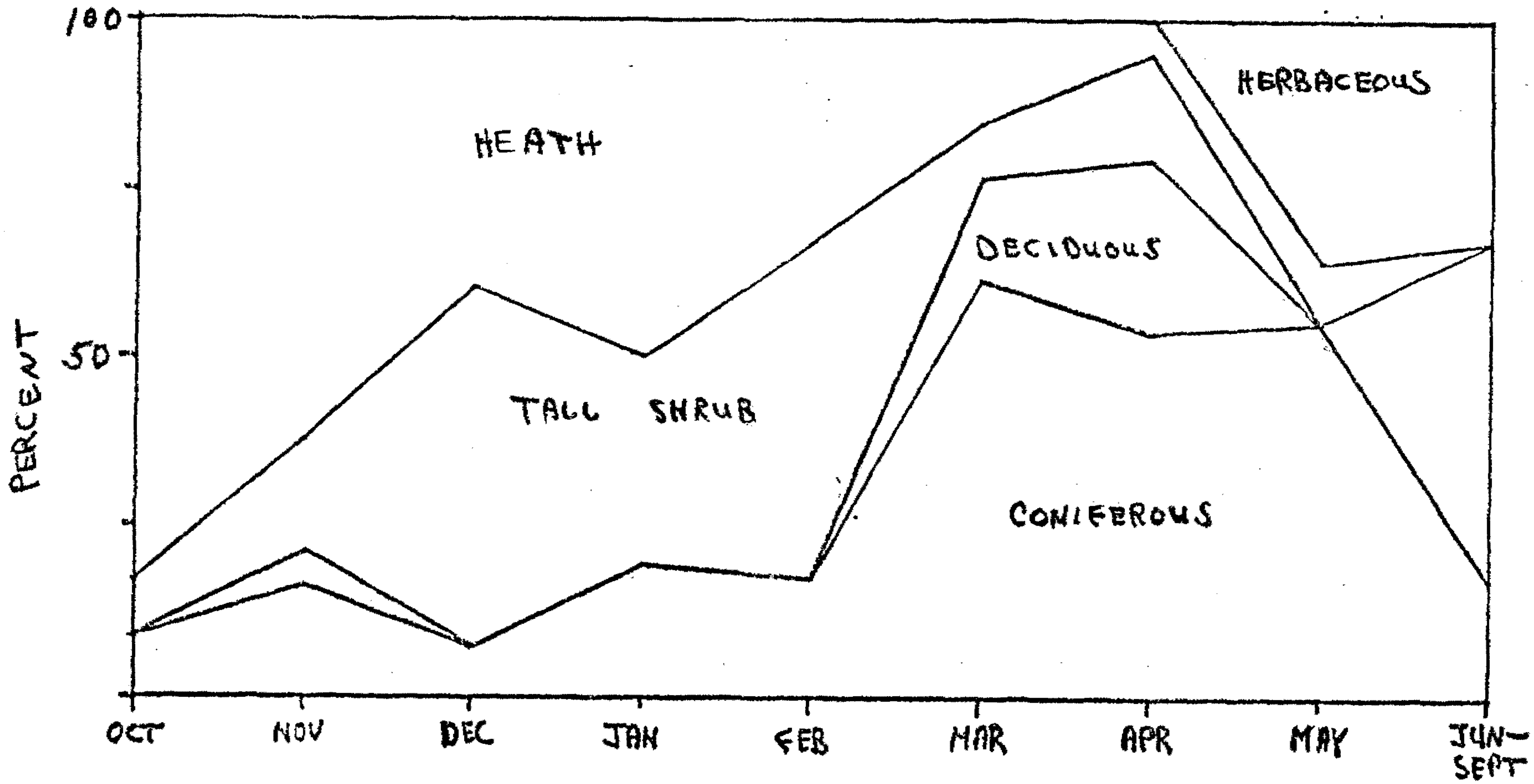


Fig. 5    Percent of total habitat use by radio-collared bull moose between 1973-1975.



## Habitat Use

Several similarities in habitat preference are shown by lone cows, cows with calves, and bulls (Figs. 3-5). All groups preferred low shrub areas during fall and early winter, although use of this habitat declined throughout the winter and reached a low in April. While closed canopy habitats of coniferous and deciduous trees were used throughout the year by all three groups, their use was greatest in late winter and early spring.

Differences in habitat preference between the three groups of moose are also apparent, although differences are smallest between lone cows and cows with calves (Figs. 3-4). Closed canopy coniferous and deciduous tree habitats were generally preferred more by lone cows than by cows with calves, while open canopy low and tall shrub habitats were utilized more by cows with calves than by lone calves. This suggests that cows with calves vs lone cows may be selecting more for high quantity and quality browse in shrub habitats (Coady and Simpson, in prep.) than for dense cover in tree habitats. Bulls also utilized low and tall shrub habitat during fall and winter and aquatic areas during summer to a greater extent than did either lone cows or cows with calves. The decrease in use of shrub habitat and increase in use of tree habitats during winter may be caused by a preference for lower snow depths in the closed vs the open canopy habitats (Coady 1974).

## Visibility

Three factors associated with the behavior of moose affect their visibility from an aircraft: habitat selection, group size and activity. Time required to sight radio-collared moose after radio location provides an indication of visibility, and therefore a relative measure of the visibility bias associated with observing moose during aerial surveys. Visibility of all groups of moose throughout the year was lowest in the heavy cover of coniferous and deciduous tree habitats, and greatest in the open shrub and herbaceous habitats (Table 4). For example, time required to sight moose in coniferous habitat increased approximately two to four times over that for animals in low shrub habibat. However, time to sight each group of moose, regardless of habitat, was similar. Therefore, while difficulty of sighting moose varies with habitat, the average visibility of cows, cows with calves and bulls throughout the year was similar.

Time required to sight moose during the months of October, November and December may be a more accurate indication of visibility bias during the season in which aerial sex and age composition surveys are generally conducted. Again, relative visibility of all groups was two to three times greater in open vs closed canopy habitats (Table 5). However, average visibility of each group in all habitats was greatest for lone cows and bulls, and lowest for cows with calves. Reasons for this difference in visibility do not appear to be related to differential habitat selection, since the proportion of lone cows and cows with calves using closed and open canopy habitats during October, November and December were similar (Figs. 3 and 4). A greater proportion of

Table 4. Average time required to locate radio-collared moose throughout the year in different habitat types. Numbers in parentheses indicate sample size.

| $\bar{x}$ Time (min) | Conifer | Deciduous | Tall Shrub | Low Shrub | Herbaceous | Total |
|---|---|---|---|---|---|---|
| Lone cows | 3.7(123) | 2.6(54) | 1.5(82) | 1.2(57) | 0.3(9) | 2.4(325) |
| Cow/calves | 3.3(90) | 2.3(22) | 1.4(66) | 2.2(68) | 0.5(9) | 2.3(255) |
| Bulls | 3.3(30) | 4.3(10) | 2.2(23) | 0.8(39) | 1.4(6) | 2.2(108) |
| Total | 3.5(243) | 2.7(86) | 1.6(171) | 1.5(164) | 0.6(24) | 2.3(688) |

Table 5. Average time required to locate radio-collared moose during October, November and December in different habitat types. Numbers in parentheses indicate sample size.

| $\bar{x}$ Time (min) | Conifer | Deciduous | Tall Shrub | Low Shrub | Total |
|---|---|---|---|---|---|
| Lone cows | 2.9(35) | 3.1(7) | 0.8(35) | 1.2(31) | 1.7(108) |
| Cows/calves | 4.5(31) | 2.0(5) | 1.3(23) | 2.4(41) | 2.8(100) |
| Bulls | 3.1(5) | 8.0(1) | 2.6(10) | 1.0(23) | 1.9(39) |
| Total | 3.6(71) | 3.1(13) | 1.2(68) | 1.7(95) | 2.2(247) |

bulls, however, occupied open canopy habitats during fall, which enhanced their visibility (Fig. 5).

Group size affects visibility of moose from an aircraft, since the probability of sighting an individual in a large group is greater than that of sighting an individual alone or in a small group. Average group sizes for lone cows and bulls differ greatly throughout the year (Fig. 6 and 7), while that for cows with calves remained relatively constant (Fig. 8). Yearly average group size for lone cows, bulls and cows with calves was 2.20, 3.98 and 2.60, respectively. This suggests that group size increases visibility of bulls and decreases visibility of lone cows throughout the year. However, average group size during the months of October, November, and December for lone cows, bulls and cows with calves was 3.23, 4.98 and 2.19, respectively. This indicates that visibility of bulls may be greatest, while visibility of cows with calves may be least during fall. This hypothesis is supported by comparing the average time to locate moose (Table 5) with their average group size during October, November and December. Cows with calves occurred in the smallest groups and required the longest time to locate, while lone cows and bulls occurred in larger groups and required less time to sight. Therefore, visibility bias resulting from differential group size may result in underestimating cows with calves in a population during fall aerial surveys.

The influence of activity (bedded, standing, moving, feeding) on visibility has not been fully analyzed, and will be reported at a later date.

Movements

Moose radio-collared and breeding in the foothills of the Alaska Range displayed four patterns of seasonal movement: fifteen moose moved from the mountains after rutting to the Tanana Flats during early winter, late winter and summer; five moose remained in the mountains through early winter, and occupied the Tanana Flats during late winter and summer; three animals remained in the mountains through late winter and moved to the flats during summer; and five moose remained in the mountains throughout the year. No differential movement patterns of radio-collared cows, cows with calves and bulls were noted during this study.

Annual distances moved varied greatly among individuals. Extreme movements were shown by a lone cow which remained within five miles of its collaring location throughout the year, and a bull which traveled a minimum straight line distance of 225 miles between different seasonal home ranges. However, most moose made annual movements of 75 to 125 miles, both totally within the mountains, and between the mountains and the flats.

The traditional nature of seasonal movement patterns is well demonstrated by this study. Observations of 10 moose during a 2-year period indicated a 100 percent loyality to seasonal home ranges. Movement patterns were described for radio-collared moose during 1973-74, and the same individuals occupied identical seasonal home ranges during 1974-75.

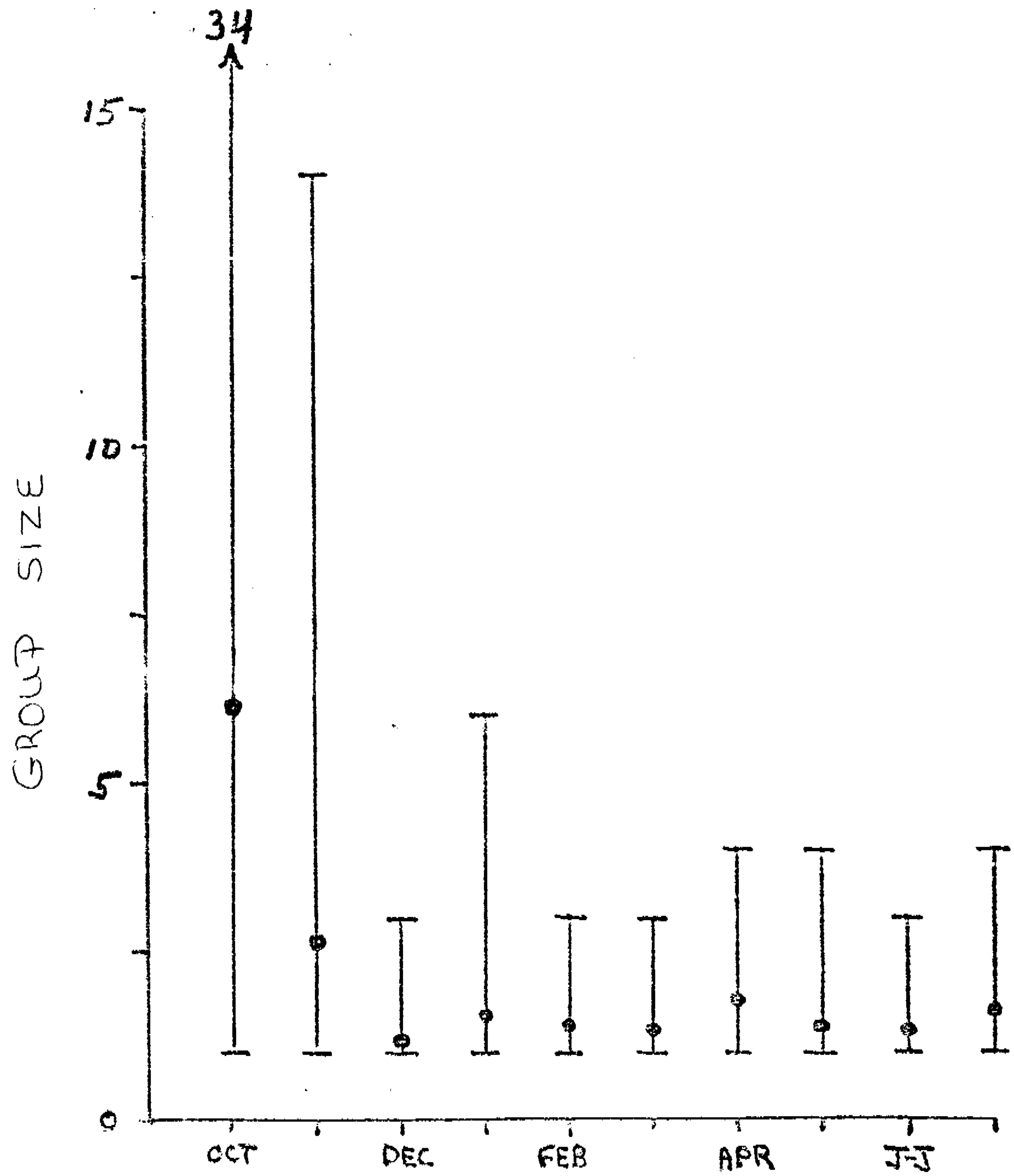



Fig. 6 Average group size and range of radio-collared lone moose cows between 1973-1975.

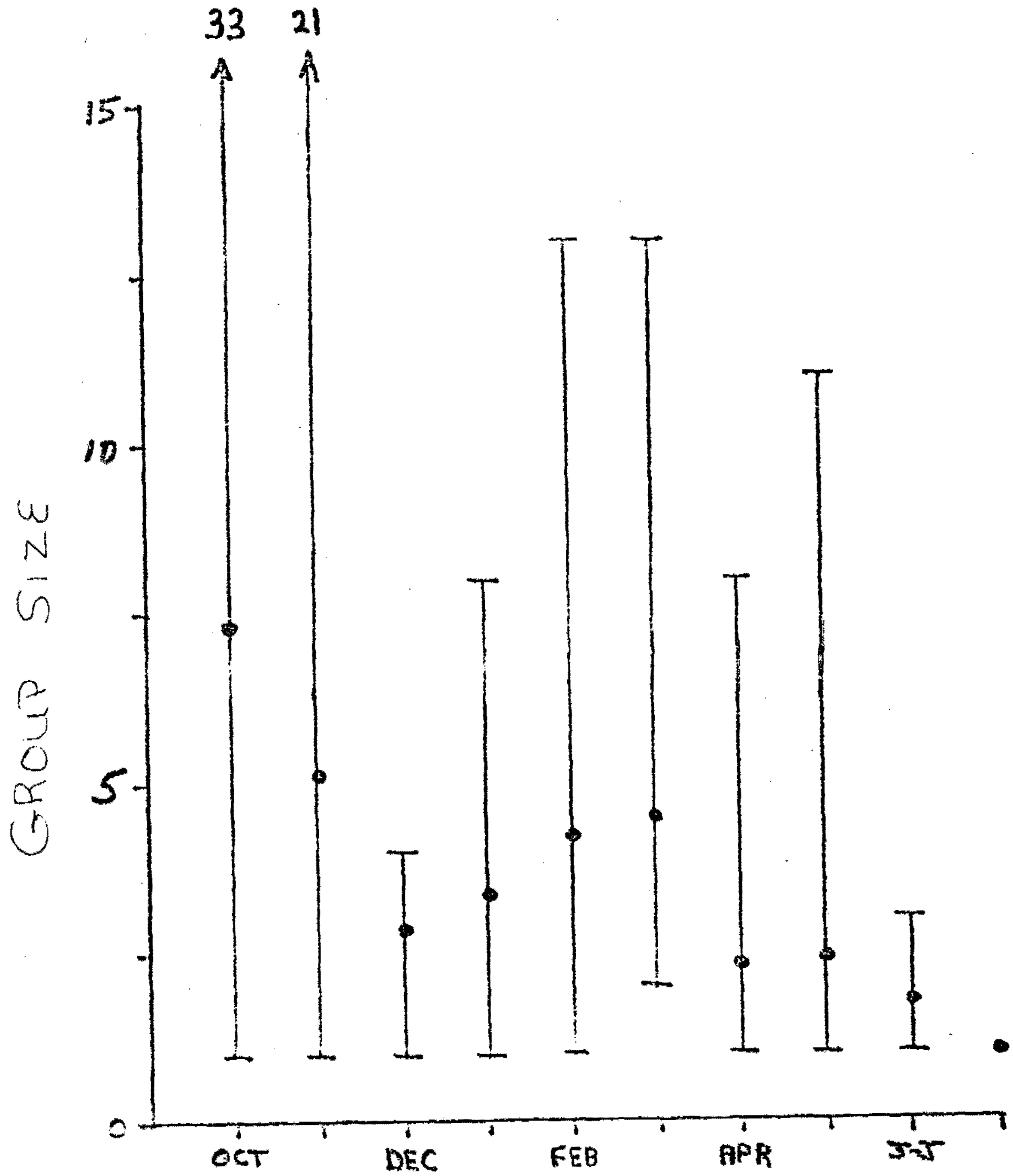



Fig. 7 Average group size and range of radio-collared bull moose between 1973-1975.

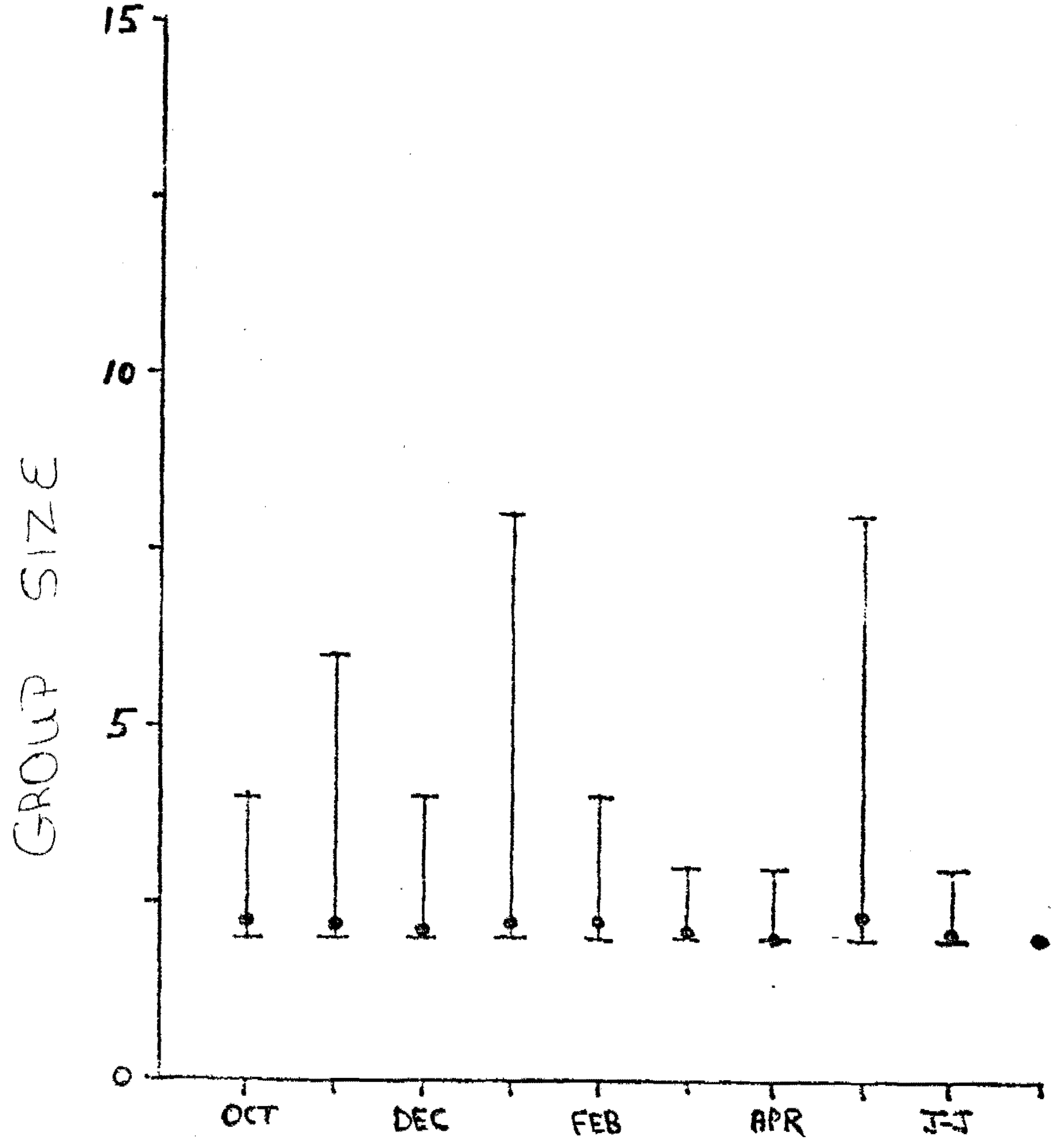



Fig. 8 Average group size and range of radio-collared cow moose with calves between 1973-1975.

Further, short-term excursions of two to four weeks to particular sites in 1973-74 were consistently repeated by individuals in 1974-75. For example, cow #10 moved a straight line distance of 20 miles from Snow Mountain Gulch to the West Fork of the Little Delta River on November 8, 1973 and returned to Snow Mountain Gulch on November 24, 1973. The same cow repeated her movement from Snow Mountain Gulch to the West Fork on November 7, 1974 and returned on December 5, 1974. Several similar examples could be cited.

The timing of seasonal movements is probably related to several factors, including climatic factors, predation and hunting and group composition. For example, movement of individual moose from the mountains to their traditional seasonal ranges on the Tanana Flats was generally one to four weeks later in 1974-75 than in 1973-74. This may have been due to shallower snow depths during fall and early winter in the mountains during 1974-75 than during 1973-74. However, seasonal movements are certainly influenced by factors other than snow, since distinct differences in summer and fall movements of individuals between 1973 and 1974 were also noted.

All findings obtained during this study will be fully analyzed and discussed and reported in future publications.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Kenneth A. Neiland

Project No.: W-17-6, W-17-7 and W-17-8    Project Title: Big Game Investigations

Job No.: 1.9R    Job Title: Disease and Winter Mortality of Moose

Period Covered: January 1, 1974 through December 31, 1975

SUMMARY

Because of mild winters and lower moose populations, there has been little opportunity to examine winter-killed moose during the past several years. Recent activities concerned with moose pathology have involved the preparation of a manuscript summarizing data on *Echinococcus granulosus*. Comparative observations on the parasites of *Alces alces gigas* (the principal subspecies occurring in Alaska) were also made on a member of this subspecies collected on a tributary of the Kolyma River in eastern Siberia.

## OBJECTIVES

The objectives of this job are to evaluate the contribution of parasites and disease to the mortality of moose.

## FINDINGS

Because of mild winter conditions and a greatly reduced moose herd in the study area (Interior Alaska near Fairbanks) we again had no opportunity to make observations on winter-killed moose. However, we did spend time on two other moose-related activities.

### A. Manuscript on *Echinococcus granulosus*

We have in preparation a manuscript summarizing all of our observations on the northern strain of *Echinococcus granulosus* Batch, 1796, a tapeworm whose larval stage (hydatid cyst) is a very common parasite of moose and other cervids. Domestic dogs and wolves (*Canis lupus*) (possibly coyotes [*Canis latrans*] also) serve as the final hosts in which larvae develop into mature strobilae. Our manuscript involves observations on the occurrence, etc. of either the adult or larval stage in over 3200 individuals of 11 species. Of these, 1116 were moose from 14 different ranges. The rates of infection varied considerably ranging from about 2 percent on the Kenai Peninsula to about 20-30 percent in the Matanuska Valley and adjacent areas. These data also indicate that the parasite is most prevalent in older females, as is clearly the case in caribou (*Rangifer tarandus*).

We are currently "marking time" on this manuscript waiting for important references to come in.

### B. Parasites of moose in eastern Siberia

As the American coordinator of Subproject A-3, "Parasites and diseases of wild animals in northern ecosystems," Project V-2.1, Area V of the Environmental Protection Treaty between the United States and the Soviet Union, I had the opportunity to initiate cooperative field work in eastern Siberia during August 1975. While our principal interest was and is in parasites of the snow sheep, (*Ovis nivicola*), a close relative of our Dall sheep, (*Ovis dalli*), we also expect to obtain comparative material from other wild ruminants. In this regard we collected a young bull moose on the Popovka River, a tributary of the Kolyma River, about 300 km north of Magadan.

The moose of eastern Siberia are considered to belong to the same subspecies as the moose of mainland Alaska, i.e. *Alces alces gigas* Miller, 1899. Accordingly we were particularly interested in determining whether this host species has similar or dissimilar parasitic faunas in Siberia and Alaska. We had originally intended to collect several animals in an area west of Magadan where moose were thought to be particularly abundant. However, bad weather prevented our going to this place for several days. Because of a tight schedule we then decided to go to the Popovka River site. While there was reasonably abundant sign of moose in that area, the days were very hot and long and mosquitoes and blackflies were present in hordes. The moose evidently stayed back in their favorite swamps and did not move about. We hunted long and hard, day and night, and finally got the small bull two days before we had to leave.

With the exception of hydatid cysts (a common parasite of Alaskan moose) which were absent in the young bull, we otherwise found six species of helminths which are the ecologic equivalents, if not identical species, to helminths occurring in Alaskan moose.

There were thousands of rumen flukes present. While these have not yet been identified, it seems likely that they may be the same species as that found in Alaska and provisionally identified as *Paramphistomum cervi* 1790, also reported in moose in the eastern United States and Canada. We hope to make a critical study of Siberian, Alaskan and Canadian material when we obtain specimens from the latter area.

Two species of tapeworms, both presumably belonging to the genus *Moniezia* Blanchard, 1891, were recovered. The true identity of the species of this genus occurring in northern, wild cervids is uncertain. We have agreed to engage in a critical review of these, including all of our material from Alaska (and the Siberian specimens), with Dr. Robert L. Rausch, one of the leading experts on the taxonomy of anoplocephalid tapeworms.

A single taeniid cyst, similar to if not the same as that of *Taenia hydatigena* Pallas, 1766, was found on the liver. Tracks of wolves were not uncommon along the river bars and one can only assume that they are the final host of the larval taeniid in that area, as elsewhere.

At least two species of trichostrongylid roundworms were found in the abomasum and small intestine. These will be determined when our Soviet cooperator, Dr. N. S. Nazarova, visits our laboratory as an exchange scientist in July 1976.

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