NATURAL SALT LICKS AS A PART OF THE ECOLOGY OF THE MOUNTAIN GOAT

by

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ABSTRACT

The role of natural earth licks in the ecology of the mountain goat (Oreamnos americanus (Blainville)) was studied during the summers of 1965 and 1966 in the Rocky Mountain Trench of southern B.C. The patterns of movements of the animals were determined as they used the licks and the vegetation, lick soils and blood serum were analyzed with respect to sodium content.

The predicated use of licks as suggested by other workers involves the idea that sodium may be the attracting element. The present study examined seasonal and differential patterns of movement, along with periodicity of use, in order to determine the resultant interplay of animal movement and sodium and water content of the vegetation.

The goat encounters such additional risks as predation, parasitism, hunting and joint use while using the lick seasonally. Since the goats use the lick differentially in time, each sex is affected to a different degree by the above factors. Differential use also produces characteristic patterns of grouping and molting.

Periodicity of use occurred mainly in the afternoon, although distance travelled and complexity of the lick may affect time of entry, length of stay and group size. The frequency of use differed at each lick, with the average time

of use by an individual being one to three weeks. Environmental factors such as temperature and weather appear to regulate the movement to and from the lick.

Analysis of the vegetation revealed that sodium was extremely low and that potassium was present in sufficient quantities to meet the requirements of the animal. No significant trends were found to exist from spring to fall or due to changes in elevation, as far as sodium and total ash were concerned.

Observations indicated that animals select certain licks over others and select sites within a lick. These high licking sites were shown to have a higher sodium content. Newly established licks had a higher sodium content than did old licks, however, highly preferred sites were not always higher in calcium, phosphorus or cobalt.

A normal range of serum sodium values was established for the goat but due to the regulatory function of the kidney, changes in serum sodium due to lick use could not be detected. Serum sodium decreased with age. A female with a kid had a low serum value. It appears that the level of deficiency causing the craving is not sufficient to show up in serum analysis.

Animals died during trapping operations and a selenium deficiency was suspected. Gross symptoms approximated those attributed to white muscle disease and the vegetation contained selenium in amounts which are known to cause this myopathy.

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INTRODUCTION

The Rocky Mountain goat (<u>Oreamnos</u> <u>americanus</u> Blainville))[1] occupies a relatively wide latitudinal range in western North America (44 degrees to 61 degrees north latitude). Within this area its ecological tolerance is probably wider than any other large mammal. Goats are commonly found down to the edge of salt water on the coast of British Columbia where annual precipitation exceeds 200 inches and on the arid slopes of Idaho where precipitation may not reach 10 inches. It is a creature of steep terrain, where cliffs are a general physical feature and where vegetation is sparse.

In general, goats do not leave the steep mountain slopes where they can find easy protection in cliffs. A notable exception occurs during the summer in the Rocky Mountains and Purcell Mountains when <u>Oreamnos</u> may leave the mountain slopes and travel through dense vegetation to reach exposed areas of mineral-rich earth locally known as "licks". The licks are seldom close to secure escape terrain or to good feeding grounds. It is apparent, therefore, that in seeking the licks the animals are expressing a compulsion so great

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1. Scientific names and authorities of mammals based on Cowan and Guiget (1965).

that it overrides the usually strong affinity for alpine-type range. The compulsion draws the animals from available range and brings them by narrow, well defined trails to areas more accessible to predators.

This poses the idea that such behavior must reflect a need, the satisfaction of which is so important to the species that the possible additional risks are tolerable at the species level.

In this region, almost all species of wild ungulates make use of mineralized earth licks or mineral springs but the distance travelled and the degrees of departure from normal habitat and habits are greater in the goat than in any other species.

The widespread occurrence of this habit among wild ungulates in the drier parts of western North America gives rise to a number of questions that require answers if we are to understand the role of the licks in the ecology of species using them. What is the nature of the demand felt by the animals; what mineral elements are they seeking from this soil and what part do they play in the physiology of the animal; why is it necessary for them to seek these supplementary sources; to what extent does the presence of these licks govern the habitability of adjacent feeding grounds; how frequently and at what seasons must the animals have access to the licks; how far will they come to reach them; what additional mortality from predation results from the habit of using licks?

There have been attempts to answer some of these questions for several of the lick-using species. In general, studies have concentrated upon attempts to determine a sought-after mineral or minerals. Thus Cowan and Brink (1949) examined samples taken from 11 licks in the Rocky Mountain National Parks of Canada in the hope that chemical analysis would reveal the needed element. Other workers, notably Honess and Frost (1942), Stockstad (1953) and Williams (1962) have used a similar approach. A second method of attacking the question has been to establish mineral "cafeterias" wherein a wide variety of elements in different formulations have been exposed to open selection by the wild species (Smith, 1954; Stockstad, 1953 and Bissel, 1953).

The present study was undertaken to gain additional information on the use of licks by <u>Oreamnos</u>. I wished to document some of the factors affecting the patterns and nature of use by the different age and sex categories, the frequency of use by the same individual, lick structure and how it affects patterns of use and the distance travelled to reach the licks. An attempt was to be made also, to gain further insight into the nature of the demand that the licks were satisfying and to determine whether there was a detectable mineral deficiency in the animals associated with deficiencies in the normal food plants.

Also to be explored were the additional risks encountered when the animals left their alpine ranges and their impact on the animals using the lick.

DESCRIPTION OF THE AREA

The study area is centered in the Rocky Mountain Trench between Cranbrook and Radium Junction (49° 30' to 50° 45' north latitude) as shown in Figure 1. The Trench is a longitudinal, glaciated depression extending from Montana to the Yukon. The Rocky Mountains rise abruptly from the valley floor on the east and the Purcell Mountains on the west begin as rounded and wooded foothills, which give way to rugged mountains (Holland, 1964).

The climate is such that there is higher precipitation in winter than in summer and a high proportion of snowfall. It is semi-arid with a range of annual precipitation of about 14 to 17 inches. The heaviest falls of rain and snow are on the western slopes (Kelley and Holland, 1961).

The area is characterized by four major vegetation zones: the Ponderosa pine-bunchgrass zone with its light and dark brown soils occurs at an elevation of approximately 2500 feet; the Interior Douglas fir zone has the orthic brown soils at an elevation of 2000 to 4500 feet; the Engelmann spruce-subalpine fir zone has orstein podzol soils at an elevation of 3500 to 5500 feet; the alpine zone with its thin humus soils occurs around 7000 feet (Krajina, 1965). The aspect of the slope will affect the elevational limits of each zone, to some degree.

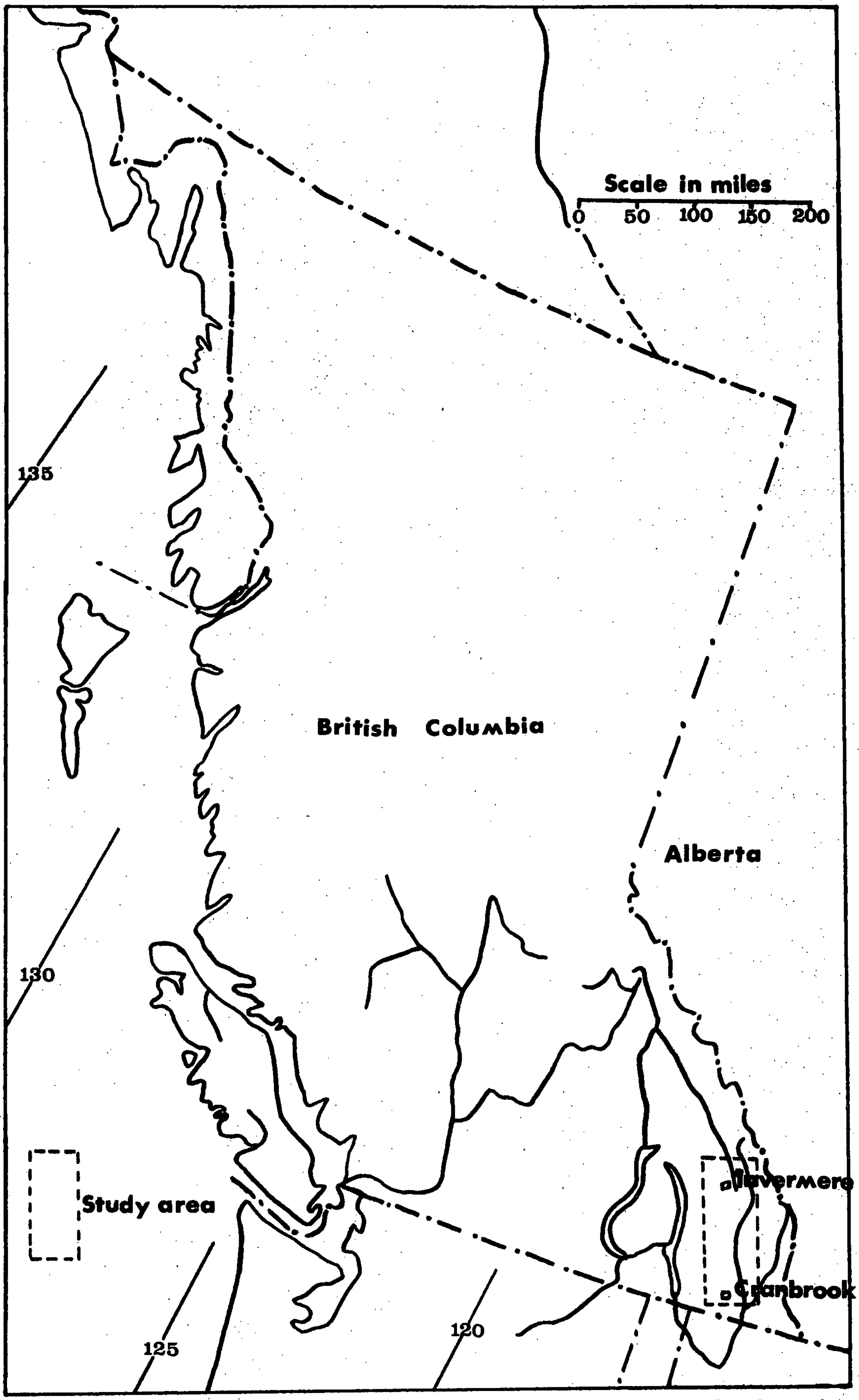

FIGURE 1. Outline map of British Columbia showing the location of the study area, in the East Kootenay region.

During the early spring, Oreamnos leaves the winter ranges and passes through the alpine and spruce-fir zones to reach licks in the Douglas fir zone. The physiography of the Douglas Fir zone is such that the animals utilize available cliffs for food, escape terrain and as a base from which they travel to the licks.

In essence, each lick is an accumulation site located on a bench or levelling off of a slope. Runoff, depending on the grade of the slope above the lick, carries minerals from higher vegetation zones to the lick region where they are deposited.

The licks in the study area will differ in degree of accumulation of minerals since the Stoddart Creek, Mary Creek, Elk Creek, and Lazy Lake licks are situated in the Rocky Mountains while the Toby Creek, Dutch Creek, and Findlay Creek licks lie in the Purcell Mountains and these two ranges differ in topography and rainfall. Although all licks are in the Interior Douglas fir zone elevational differences among lick sites cause some licks to border the spruce-fir zone and others the bunchgrass zone.

The Stoddart Creek lick at an elevation of 2900 feet is on a south facing slope which borders the open park-land of Douglas fir-bluebunch wheatgrass. The stretches of grassland on drier slopes contain bluebunch wheatgrass

(*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and June grass (*Koeleria cristata*) and serve as sheep (*Ovis canadensis*) winter range since snowfall is usually low.

The Toby Creek lick on the north-facing bank of the creek is at an elevation of 3000 feet. It is centered in the Douglas fir-pine grass subzone of the wooded foothills of the Purcells which may to some extent serve as moose (*Alces alces*) winter range.

The Dutch Creek and Findlay Creek licks border the spruce-fir zone at an elevation of about 4000 feet. They are both on west facing slopes in an area of high snowfall.

The Elk Creek and Mary Creek licks in the Rockies, border the spruce-fir zone at an elevation around 4500 feet. Both are found on southwest facing slopes where elk (*Cervus canadensis*) migrations are common.

The Lazy Lake lick is situated on a southwest facing slope at an elevation of 4000 feet. It borders the Ponderosa pine-bunchgrass zone since the Rockies rise abruptly in this region and elevation becomes less important in separating zones. The area is extremely dry with a light snowfall in winter.

The behaviour of the mountain goat during the spring and summer leads it to occupy three elevational regions for varying lengths of time. As the winter snow recedes goats move into the alpine and subalpine zones which serve as summer range for approximately six months. Animals leave this range for short periods to travel to natural earth licks to acquire minerals. While in the vicinity of the lick they occupy a region which is essentially a modified form of their summer range. It offers escape terrain in the form of cliffs, food, cover and bed sites. In general, this region is about 1500 to 2000 feet higher in elevation than the respective lick, while the summer range occurs between 6000 and 8000 feet. These three regions may be designated 1, 2, and 3 and occur to a greater or lesser degree at each lick studied. For any of the licks studied, region 1 is the summer range the lick serves; region 2 is the temporary safety area close to the lick used while the animal is preparing to visit the lick proper, or between several visits to the lick in quick succession; region 3 is the lick itself.

METHODS AND MATERIALS

The methods used during this study consisted of field methods to determine patterns of use and laboratory methods to determine mineral content and to detect mineral deficiencies of the vegetation, animals and lick soils. Observations in the field were designed to show, at the licks, frequency of use by the same individual, differential use in time by the sexes, movement between designated areas and the relation of the factors affecting these patterns. The laboratory methods compared mineral content of forage species during the spring, summer and fall seasons at different elevations and mineral content of the blood before and after lick use to see if deficiencies could be detected. Lick samples were analyzed to see if the mineral content was sufficient to supplement deficiencies in the plants.

Trapping

The two main purposes of trapping were to obtain blood serum samples and to mark animals so that information could be obtained regarding patterns of movement. Two types of traps were used during the study. Permanent corral traps built on well defined trails had a gate on one or both ends and were operated by a trigger rope. They were approximately 8 feet high, 20 feet long and the width varied depending on the trail. Each was lined with chicken wire in case poles came loose during any struggle by the animal. The trap at Dutch Creek had two gates while those at Toby Creek and Findlay Creek had only one.

Two moveable box-type traps were obtained from the B.C. Fish and Wildlife Service for use during the summer. They were approximately 5 feet long, 4 feet wide and 4 feet high. They had a gate at one end, were covered with $\frac{1}{4}$ inch thick, 2 inch rope mesh and had a frame made of $\frac{1}{2}$ inch black pipe.

Marking

Trapped animals were marked by painting their horns with coloured enamel from spray cans. A different color was used for each animal at any one particular lick. Also, a number approximately 1.5 to 2 feet high was painted on both sides of each animal.

Animals were marked without trapping using two types of automatic marking devices. The simpler device consisted of a rat trap, an egg filled with histological dye and a trigger string. The device was assembled on a strip of plywood 4 inches wide and 6 feet long and suspended above a trail entering the lick. Twenty of these devices were used during the summer. The eggs were filled with histological dye using a 250 millilitre veterinary syringe. A trip string was made of 25 pound test nylon fish line. A piece of wire was attached to the snap wire of the trap, to cut the egg cleanly, allowing the dye to drop directly down onto the animal. Dye colors were rotated in each device during the summer.

The automatic spray device was adapted from Clover (1955). It consisted of a pressure tank containing dye and 120 pounds air pressure, a nozzle to direct the flow and a pressure treadle triggered by the animal to release the dye.

The method used to prepare the dyes was taken from Hansen (1963). The dyes used were rhodamine B extra, malachite green crystals and picric acid. These gave pink, green and yellow colors, respectively. Green and pink solutions were mixed to give violet. The pink and green dyes were prepared by dissolving rhodamine B extra or malachite green, respectively, in 1 pint of a 99 percent solution of isopropyl alcohol. To this an equal amount of water was added. The picric acid was made into a saturated solution with isopropyl alcohol and an equal amount of water added.

Vegetation

Before forage species were collected to determine mineral content, rumen samples from 5 goats shot in the study area were examined to get a relative idea of the food types. Samples were preserved in 10 percent formalin. The material used for examination was strained, washed and food types in the form of grasses and sedges, forbs, shrubs and conifers were separated. The displacement technique, employing a graduated cylinder filled with water was used to determine the volume of each. From this, each food type was calculated as a percentage of the total.

Animals feeding in the vicinity of the licks were observed to see which forage species were being utilized.

Forage species were collected from May until September during the summer of 1966 with an attempt being made to collect plants in the same phenological growth stage. The actual collecting consisted of taking 10 to 20 annual-growth stems (including leaves) from as many individual plants as possible, for each species.

Plants collected in late May (spring collection) were taken from the vicinity of the lick. In early June plants were collected from region 2. In late June and early July plants were collected from region 1. Since receding snow cover limits spring growth, plants at higher elevations began to grow and mature later. Therefore, plants collected in region 1 should have been at approximately the same growth stage as plants collected at the lick.

During late August and early September the same species were again collected at the same elevational sites. Plants at all sites were completely mature with seed-heads and berries abundant. Although plants collected at the lick had been in the maturation stage longer than plants collected in region 1 this factor was not expected to alter the results, as precipitation and consequent leaching had been negligible.

New-growth stems of the browse species involved were removed at the nodes and grass was clipped just above the base (Dietz et. al. 1962). Each species was placed in a paper sack marked with the date, species, lick and elevational site. All samples were air dried during the summer. Larger and coarser samples were ground in a hammer mill; smaller samples were ground in a Wiley mill. The ground material was mixed and placed in glass bottles until needed for subsequent chemical analysis.

As far as possible all plants were collected at Toby Creek. In some cases, plants from regions 1, 2 or 3 at other licks were used when the particular species could not be obtained at Toby Creek. Since licks are accumulation sites, it was supposed that plants collected at the same elevational regions at other licks would be under approximately the same conditions of leaching and movement of minerals down the slope.

Analysis for sodium and potassium in the plant was done as described by Chapman and Pratt (1961). Approximately 3 grams of each sample were placed in a crucible and dry ashed at 600 degrees fahrenheit. The ashed material was dissolved in 20 percent HCl and diluted to 100 millilitres with distilled water. The contents were placed in flasks and stoppered until needed. Standard curves for sodium and potassium were plotted for the Perkin-Elmer flame photometer and the unknown solutions run accordingly. Concentrations as percent dry matter in the plant were calculated from the curves and are shown in Tables 15 and 16.

Lick Soils

Lick samples were collected from the Dutch Creek, Toby Creek, Mary Creek and Lazy Lake licks so that two types of samples were taken from each lick. Observations showed that licks are composed of high-licking sites and low-licking sites which may or may not be adjacent to one another. Surface material was collected from each site so that it represented what the animals were actually licking or refusing. The material was put through a screen, air dried and stored in glass jars.

Soil samples were analyzed using the method adopted by Stockstad (1953), described below. Chemical analysis was carried out on 11 samples from 3 licks. All soil samples were treated with ammonium acetate at two pH levels. The amount of each element available to the animals using the licks was approximated by using buffered extracting solutions with pH values similar to those found in a ruminating animal's abomasum and intestine. A series of pH determinations on the digestive tracts of 30 elk and 42 deer indicated that pH values of 4.00 and 7.00 should be used. Phosphorus concentrations were determined using the Bray method for extraction purposes. The actual determinations, for all elements, were made by following the procedures outlined by the Association of Official Agricultural Chemists (1960).

Blood

Blood samples were taken in the field using vacutainer tubes and needles. The vacutainer tubes drew approximately 10 millilitres and contained no anticoagulant. The needles were 1.5 inches in length. All samples were taken from the jugular vein. Capillary tubes containing heparin as the anticoagulant were used to obtain hematocrit values. Test tubes containing heparin were substituted in June for the capillary tubes due to loss and breakage.

Blood samples kept cool in an insulated cooler were transferred to the cooler in the Kimberley Hospital within two hours after the sample was taken. The serum was separated on a centrifuge and analyzed for sodium using a flame photometer with an error of plus or minus two percent. The heparinized samples were centrifuged and the packed-cell volume determined as a percentage, from a known volume of blood. All analyses were done by the laboratory technician in the Kimberley and District Hospital.

RESULTS

LICK STRUCTURE

The dry earth licks are formed naturally and the great variation in size and structure among them causes differences in patterns of use.

Each lick is located in an accumulation site and has a trail system between regions 1, 2 and 3 that is similar in basic design. The licks differ in size, structure and complexity. Within the lick, the actual licking site may be a small moist pocket of clay, a cavity beneath a Douglas fir tree or a combination of the two.

Trail systems

The structure of the trail system is such that each lick is connected by a well defined trail to region 2 and region 2 has a network of trails branching from one main trail which leads into alpine summer range. Each lick is bounded on 3 sides by well defined trails so that goats can enter or leave the lick on two sides and join with the trail from region 2 on the third side. The fourth side usually has a river or creek forming its boundary. The trail between region 2 and the respective lick passes through dense timber, does not branch or split and is about ¼ to 1 mile long. The trail from region 1 to region 2 passes through the Douglas fir zone, the spruce-fir zone and into the alpine zone. It may be 5 to 15 miles long and follows ridges and skree slopes.

A description of the use of trail systems is needed to show the specificity of movement from one region to another and the degree of selectiveness goats show between major and minor licks. In the early spring, the males move from their winter ranges to region 2 where they begin feeding on succulent forage. From region 2 they make frequent trips to the lick and for about two weeks can be found in the lick or region 2. They then move onto their respective summer ranges. At no time during the spring or summer was shed hair or fecal material found anywhere but on the trail system between the three regions. Goats did not appear to wander, as deer do, but used the trails to reduce travelling time between regions. This made them less vulnerable to predators and they spent less time in habitats low in palatable forage. At the Toby Creek lick, on two occasions, goats were found wandering down a road which crosses the trail between region 2 and the lick. It appeared as if the goats had missed the trail while crossing the road and, as they moved down the road, had examined each opening into the brush. As none of the openings were connected to the trail they kept moving down the road. In both instances they moved back up the road and eventually found the trail. In neither case did they move through the timber to reach region 2. Kids, when separated from their mothers in the vicinity of the lick always returned to the trail leading to region 2 rather than move through the timber. More wandering occurred between region 2 and region 1 when the trail was above timberline. This was attributed to the animals moving to individual summer ranges and to the increase in palatable forage species.

The movement of goats between regions is very definite and the trail system is used to increase efficiency. In much the same way, goats are very efficient and selective in the licks they use. At the Dutch Creek, Lazy Lake and Stoddart Creek licks a major and a minor lick were present. In all 3 instances, the minor lick was more accessible and closer to region 2. The goats would move past minor licks and utilize a major lick. Use of the minor lick increased at the Dutch Creek and Stoddart Creek licks over the summer but this was probably caused by trapping operations at the major lick. The goats were very selective in the lick they chose and also very selective in the actual licking site within the lick. At Lazy Lake, the trail passed through a minor lick north of the major lick yet little or no licking occurred except in the major lick. The cavities in the minor lick appeared older and contained more rock. The minor licks were smaller than the major licks in all instances.

Size and structure

The licks differ so greatly in size and structure that a detailed description of each is not possible. The Toby Creek lick is about 2 miles long and 200 yards wide; the Dutch Creek lick is about 100 yards by 200 yards; the Lazy Lake lick is about 300 yards by 400 yards and the Stoddart Creek lick is about 100 feet by 200 feet. The Stoddart Creek and Dutch Creek licks are open clay pits providing no cover or escape terrain. They are very exposed and the hot summer sun of July and August keeps the clay hot and dry. The Lazy Lake lick has all licking sites among the roots of Douglas fir trees. The Toby Creek lick has strips of timber, 3 small clay pits among the roots of Douglas fir trees in a timbered section, escape terrain in the form of steep cliffs and exposed clay banks. The complexity of the lick is determined by comparing the habitat features of region 1 to those found in the lick. The Toby Creek lick is the most complex since it contains almost all the habitat features found in region 1. The Lazy Lake lick contains timber, some palatable forage and some escape terrain. The Stoddart Creek and Dutch Creek licks are the least complex, being only exposed pits having no other habitat features. The Dutch Creek lick contained some palatable forage around its edge.

PATTERNS OF MOVEMENT AND LICK USE

Introduction

The actual salt requirements of big game have never been extensively investigated and no knowledge of a nutritional necessity is available. Inasmuch as it has been conclusively demonstrated that both sodium and chlorine are essential for most animal life, a physiological necessity existing in wild ruminants would be no exception. Since sodium is not considered necessary for normal growth of most plants, it is highly debatable whether a certain range can fully satisfy the physiological requirements of sodium in the animal. The chemical nature of the range would to a great degree determine the nutritional requirement of salt in ungulates.

The importance of the patterns of movement exhibited by the mountain goat is seen when we realize that they place the animal on ranges varying in chemical composition. They also serve to determine the degree of contact with other species, parasites and predators. It is necessary that these patterns be described and understood in order to assess the vegetative conditions an animal encounters prior to entering the lick. In order to show that the diet of the goat can not supply sufficient sodium, the feeding patterns in relation to the mineral content of the forage must be correlated.

It has been suggested that ungulates use licks in an attempt to supplement a diet low in mineral content. This leads to the conclusion that there are many minerals which could be deficient in the vegetation and which could attract the animals to natural licks. Evidence is being accumulated to show that spring forage conditions may play an important role in initiating lick use. Dalke et. al. (1965) found that a conspicuous salt hunger in elk developed 2-3 weeks after early use of succulent forage. It would seem that a winter diet low in sodium, would, upon eating spring forage high in water content with little or no sodium, induce a physiological state in the animal whereby sodium was deficient. It has been found by Marriott (1950) that "pure salt depletion" occurs in patients who become deficient in sodium and chlorine while being liberally supplied with water. A patient on a salt deficient diet lost 5.96 grams of sodium in the first 10 days but after that the kidney, in its regulatory function, greatly reduced the sodium output. All studies with mineral cafeterias have shown conclusively that sodium was the important element sought after under the prevailing conditions (Stockstad, 1953; Bissel, 1953 and Smith, 1954).

The present study will attempt to relate patterns of movement of the goat to the sodium concentration of the forage, the lick soils and the blood serum of the animals.

Seasonal patterns

In the Rocky Mountain Trench of British Columbia natural mineral licks are abundant and widely distributed. They appear attractive to large populations of wild ungulates, although little is known about the patterns of use by individual species. Licks situated at the lower edge of the Douglas fir zone are adjacent to winter feeding grounds of bighorn (Ovis canadensis), moose (Alces alces), elk (Cervus canadensis) and mule deer (Odocoileus hemionus). Licks at higher elevations lie on the migration routes of these species and are utilized during the spring migration. In general, mountain goats winter at high elevations on exposed wind-swept slopes or adjacent timber and cliffs, while the above mentioned species winter in the bunchgrass zone or adjacent timber. This trend reverses somewhat in the summer; individual goats travel to natural licks at low elevations while other species move to alpine regions. The shift occurs in May and June as the snow pack recedes. The big game species mentioned, with the exception of the goat, move into the vicinity of the licks in late fall (November) and remain there until late spring (June), having access to the licks for approximately 8 months. The goat uses licks from early spring (April) to early fall (September). Dalke et. al. (1965) states that use of salt licks by elk was nil during February and March, and there was no evidence that elk pawed through the snow to gain access to the salt. Deer, sheep and caribou have been observed licking salt in the winter, on roadsides, where man has spread it to improve road conditions. There is no evidence to suggest that goats use natural or artificial salt licks at any time during the winter months.

The use of licks in this area, by ungulates, produces a concentration of big game species in the vicinity of the lick during the latter part of April, all of May and initial part of June. Mineral springs are rendered unavailable in winter by freezing but clay from earth licks is probably available since material is chewed. This leads to the conclusion that seasonal concentrations of ungulates are based upon factors other than those of availability of lick soils. Artificial salt licks were used by elk on their migration only as the upper edge of activity reached them. No pawing down in the snow to reach salt licks ahead of time was noted, while elk were seen to dig as deep as 48 inches in snow for certain desirable food plants. The apparent centre of elk activity was well below the licks for some time after they had become snow free (Beeman, 1957).

The initiation of lick use by mountain goats would seem to be an extremely variable factor. It appears to be affected by elevation and receding snowpack, spring vegetation and weather. The first day of use is recorded for each lick in Figures 2 and 3. Figures are for the summer of 1966 since work was not started until June in 1965. Initial use was mainly by males according to observations made in early spring. The numbers were very low during early May but gradually increased until a peak was reached in June. The majority of goats were observed feeding rather than licking upon descent to low elevations. This suggests that initiation of lick use more accurately describes movement into the vicinity of the lick.

Termination of use at each lick varies in relation to the total period of use from the initiation of lick use. High elevational licks such as Dutch Creek and Elk Creek had goats using them on August 15, 16 and 23; with probable use to the end of August or early September. Records of goats shot in the Dutch Creek lick in September of previous years attest to this statement. Goats using low elevational licks such as Toby Creek and Stoddart Creek terminate lick use around the end of July. Only one female and kid were seen in the Toby Creek lick at this time and only one lone adult at the Stoddart Creek lick. After this, no tracks or sign of animals using the trail could be found.

In general, low elevational licks are used early in the spring with termination of use occurring in late summer.

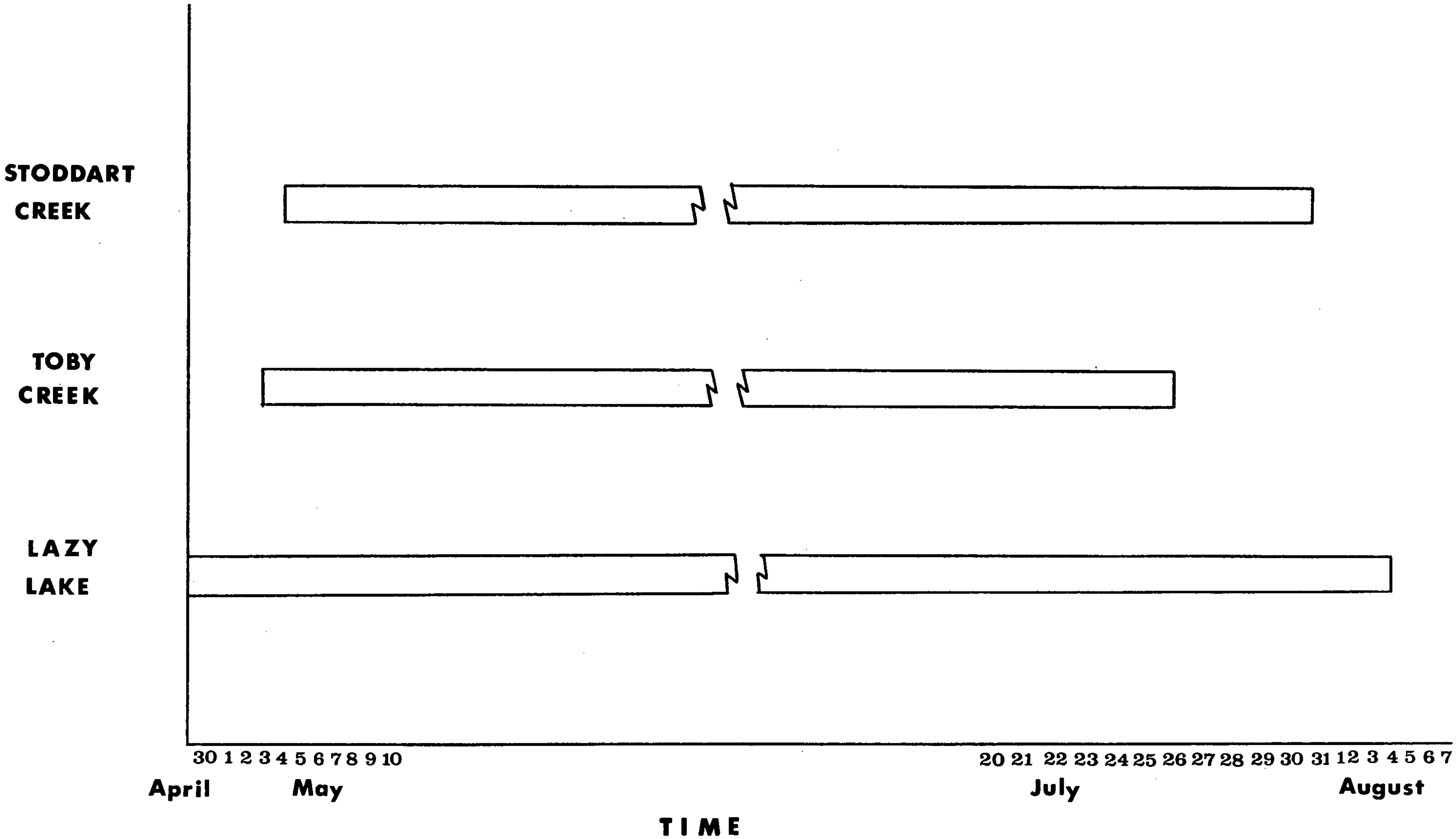

FIGURE 2. The initiation and period of use at three low elevational licks during the spring and summer of 1966

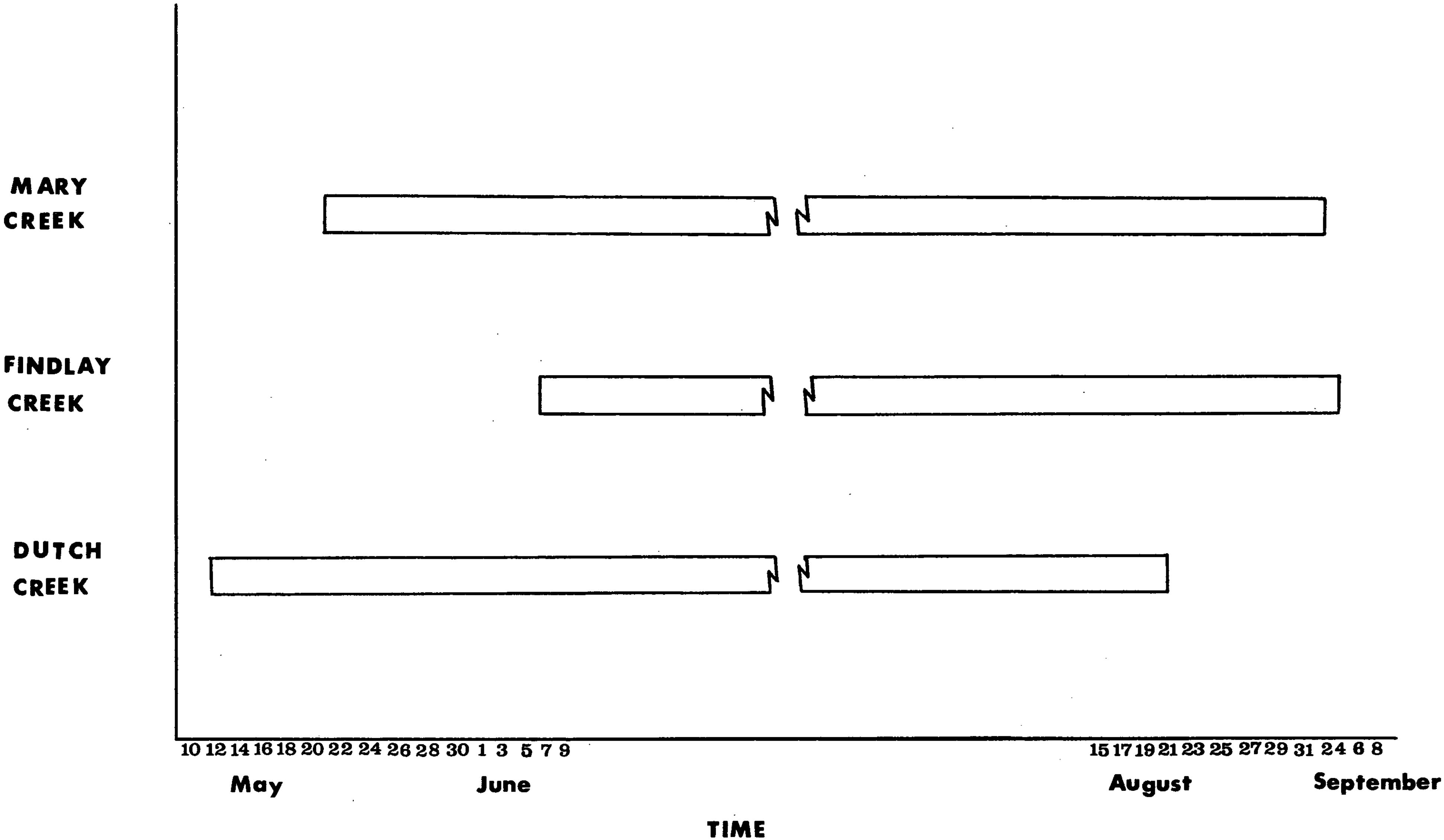

FIGURE 3. The initiation and period of use at three high elevational licks during the spring and summer of 1966

High elevational licks are not used until late spring but use continues later into the fall. The total period of use appears to be similar for these two groupings of licks.

Elevation appears to be an important factor regulating initiation of use and total period of use. In general, the licks at low elevations, used during April and May have a reduced snow cover and the surrounding area supports early spring growth. The Lazy Lake lick probably receives the least snow and has the earliest growth of vegetation, since it is on an exposed southwest facing slope bordering the bunchgrass zone. The snow recedes by late April, exposing the whole face, and spring growth begins in May. Goats observed at this time are at elevations approaching that of the lick or lower. In most cases they were seen feeding on a low cliff (at 3000 feet) which rises abruptly from the valley floor.

At Toby Creek and Stoddart Creek, initial use was somewhat later. Region 2 at both licks is a north facing slope which retains its winter snow pack. Males, first to arrive, fed on the lower edge of the cliffs, after spending much time in small openings in the timber below the cliffs.

The high elevational licks such as Dutch Creek and Mary Creek retain their winter snow longer and are more susceptible to spring snow storms since region 2 occurs between 5000 and 6000 feet. In May, at the Mary Creek lick, region 2 was covered frequently by spring snow storms. Two sets of cliffs are spaced one above the other, above the lick, one about 1000 feet higher than the other. The top set contained winter snow into late May while the lower set was often covered with snow from spring storms.

At the Toby Creek and Lazy Lake licks a definite pattern of feeding existed from initial use in the spring to termination in the fall. There was a continual increase in the elevation of feeding sites over the summer. In early spring, the goats at Lazy Lake fed at the elevation of the lick or lower, and the goats at Toby Creek fed on the lowest cliffs. By the end of May or early part of June the animals at Lazy Lake were ranging in the region of the pinnacle and cliffs around it (approximately 1500 to 2000 feet higher than the lick). At Toby Creek the animals were using the lower cliffs on the west side of region 2. By the end of June or early part of July when the females began moving in, feeding occurred on the upper portion of the cliffs. By the end of July most animals were seen on the higher cliffs on the east side of region 2. Very few animals were seen on the lower cliffs and those that were seen were usually just passing through. At Lazy Lake, at this time, the same trend occurred with fewer animals seen around the pinnacle and more moving in from region 1 daily.

Succulent spring vegetation as a determinant of seasonal patterns

It has been shown that goats use natural licks only in the summer, that feeding on succulent vegetation usually precedes lick use and that goats feed at progressively higher elevations during the summer and are probably feeding on plants in an early stage of growth for most of the summer. According to Table 3, at least 87 percent of the goats observed at the Lazy Lake and Dutch Creek licks were not in the lick during May. In April, all goats were observed feeding and none licking. In June, 72 percent of the observations showed goats licking and 28 percent of the observations showed them feeding.

Recent studies have shown that utilization of succulent forage in the spring may contribute to initiation of lick use. Dalke et. al. (1965) found that prior to the middle of May, the appetite of elk for new vegetation was greater than the desire for salt and that salt grounds within the succulent herbaceous areas were used considerably more than the licks in shrubby areas. He also found that the extent to which each of the natural licks was utilized by elk during any one period of the spring and summer depended chiefly upon the elevation of the lick and its location with respect to the various elk populations and the more preferred secluded areas. Williams (1962) found that the advent of green vegetation at the lower elevations attracted and held the animals in the lower areas during a period from about mid April to the first of May. The elk migration or upward movement, once commenced, proceeded concurrently with the progress of forb, sedge and grass development and it was during the gradual upward movement that concentration on salt grounds first became prominent. This movement of elk due to spring growth is similar to that found in goats at both the Toby Creek and Lazy Lake licks. The fact that use of succulent vegetation precedes lick use may indicate a factor determining both the seasonal pattern of movement and the initiation of lick use. It would suggest that the kidney can compensate for a winter diet low in sodium but cannot maintain homeostasis in the spring when ungulates increase their water intake on a low sodium diet. According to Kerr (1965) the downward movement of goats in spring is probably a response to new vegetative growth which begins to appear on the lower mountain slopes at that time. There appeared to be a correlation between the elevation at which animals were found and the new vegetative growth.

As described, big game species winter at low elevations in this area and so take advantage of succulent spring growth. They have a short distance to travel to the lick while the goat must travel long distances to capitalize on succulent vegetation and licks. Klein (1953) suggests that the lack of available forage and shelter in the high summer ranges during winter months causes fall movements from the alpine summer ranges to the subalpine fir forests. The spring dispersal from the winter to summer range is governed by the rate of upward retreat of the snowline. Wintering bands of goats move to the upper fringe of timberline with the first warm days of spring and remain in this area until the snow cover has left the higher treeless slopes.

It appears then, that the pattern of feeding in the spring and seasonal use of licks by big game could be determined by the water and mineral content of spring vegetation.

Seasonal patterns of movement invoke additional risks

Since the density of big game species increases in the vicinity of the licks in early spring, it was thought that the presence of other ungulate species might affect the seasonal use of licks by goats. In this sense, joint use among ungulate species was examined. Summer use of licks also affects the goat adversely by bringing it into contact with large populations of the paralysis tick (Dermacentor andersoni). At this time, goats encounter a greater abundance of predators and hunting pressure in the fall. This suggests that the benefits derived from lick use outweigh the sum of the negative factors and leads to the perpetuation of the species. The effect of each negative factor does not affect each sex to the same extent and will be explained from a viewpoint of differential use in time.

Interspecific joint use controlled by seasonal patterns

Virtually no interspecific competition for lick use was observed at the various licks. On some occasions other species besides goat were seen in the lick. Almost no other tracks, shed hair or fecal material was found in the lick. Moose and whitetailed deer had home ranges in the vicinity of the Toby Creek lick but neither species was observed in the lick.

In early June, both elk and goats were observed at the Mary Creek lick. At this time elk were migrating from their winter to summer ranges and many paused at this high elevational lick which is at the lowest point of elk summer range. Intensive lick use by elk occurred in the early morning, late evening and at night. Goats used the lick mainly in the afternoon. Little use was observed in the morning or evening. Specific lick sites were found in the bank at two different heights; those made by elk, being two to three feet higher than those made by the goat. Most elk were observed licking on the east side of the lick and most goats on the west side. Elk use was most intensive during the last week of May and early part of June when goat use was just beginning and least intensive. It appears that joint use by two ungulate species existed at this lick for a short period but interspecific competition was negligible due to behavioural differences. Since the elk migration is timed to follow the growth of spring forage, it would appear that this is a major factor bringing both species to the lick at approximately the same time.

Goats, sheep and mule deer frequent the Lazy Lake lick during May and June. Both sheep and deer were observed using the lick and droppings and shed hair attested to their presence. Goats were never observed in the lick at the same time as sheep or deer. The majority of goats were observed feeding on a low cliff north of the lick in April and May, and in June most sheep and deer migrated to summer ranges. Although joint use existed it does not appear that competition reduced available lick use to goats.

No evidence of competition or joint use was observed at the Dutch Creek lick. Mule deer, elk and moose were seen feeding in the vicinity of the lick, but no tracks, shed hair or fecal material from these species were found in the lick.

At Stoddart Creek the lick is about one mile from sheep winter range. Local counts show that about 100 sheep are present over the winter. At no time were sheep seen in the lick; sheep tracks, fecal material or shed hair were not found in the vicinity of the licks. Sheep migrate to summer ranges in Kootenay National Park where licks are abundant and this may be the reason joint use did not occur at the Stoddart Creek lick. Also, this lick is in the Douglas fir zone which provides little available forage. Goats utilize forage on nearby cliffs but sheep do not appear to travel through the timber between the bunchgrass zone and the lick.

It does not appear that competition is important in limiting lick use by goats but joint use by other species is common. Behavioural traits common to the species keep each from infringing on the other's activities. Joint use occurred at high and low elevational licks so that no obvious relation appeared to exist between elevation and lick use. Those licks which are situated near the bunchgrass zone or in the path of the spring migration have a greater tendency toward joint use than those which occur in heavy timber. This leads to the idea that the vegetative zone supplying the best winter range increases joint use. Joint use occurred only in the spring when ungulates were concentrated on areas of new spring growth. As sheep, deer and elk moved to their summer ranges joint use decreased in intensity.

INFLUENCE OF SEASONAL PATTERNS ON EXTERNAL PARASITE LOAD, PREDATION AND HUNTER KILL

During the spring when big game species are centred in the bunchgrass zone and Douglas fir parkland, the paralysis tick comes out of hibernation. It attacks game animals in the spring of the year from about March to May, with a few still active in June. The goat is present in this vegetative zone at this time. Males trapped in early spring bore large numbers on most of their body; approximately six in an area covered by the palm of one hand. It has not been shown that this tick causes Rocky Mountain spotted fever in big game but they may be of serious consequence, by draining the host's vitality when it is in an already weakened condition from winter food shortages (Cowan, 1951).

Predation

Cowan and Brink (1949) state that an important result of the attraction that licks exert upon game is the exposure to predation that ensues. Almost all goat kills that they found were adjacent to licks.

During two summers field work at six licks no goat kills or remains were found. The three low elevational licks (Lazy Lake, Toby Creek, Stoddart Creek) have such predators as black bear and cougar. The high elevational licks have these two predators as well as grizzly bears. Black bear were seen at the low and high elevational licks; grizzlies at some high elevational licks and cougars were not seen at either, however fresh cougar tracks were seen near the Lazy Lake lick. Although many trips were made through regions 1 and 2 and the lick, at the various lick sites throughout the summer, no evidence of predation was found. On numerous occasions black bear were seen at all licks. The female goat trapped during late July at Toby Creek was kept in a pen for two weeks near the lick. On three separate occasions black bear were seen feeding on Shepherdia berries (buffalo berries) within 100 feet of the pen. The goat did not seem disturbed by the bear's presence and the bear did not bother the goat. These were not repeated observations on the same bear.

The cougar population has been reduced in this region due to bounties and paid predatory hunters; causing a decrease in cougar predation. It seems significant that only one set of cougar tracks was found during two summers of field work.

Predation does not seem to be a very important negative factor affecting lick use.

Effect of the hunting season on lick use

The termination of lick use was related to the opening day of hunting season for the two summer study periods.

In 1965, there were reports of approximately 8 to

10 goats shot in licks or in areas adjacent to them. Although this is not extremely high, it is important because most animals were females. A female was shot at Lazy Lake on September 8, one at Findlay Creek on September 1, three at Dutch Creek and two females and a yearling in the vicinity of the Elk Creek lick. The opening day of hunting season was August 24. These licks make up a very small part of the total number present in the East Kootenay.

In 1966, the hunting season did not open until September 3. No reports of goats killed in the licks were received by September 20, although many people said that they had hunted the licks. It seems that lick use had been terminated and the goats had moved to other ranges. The licks at a low elevation had a lower goat kill during both summers than the licks at a high elevation. The later opening of the hunting season shows a reduced kill in the licks although temperature and weather may affect this also.

PATTERNS OF DIFFERENTIAL USE IN TIME

I have shown that both sexes of the mountain goat use licks during the summer. It is the purpose of this section to explain differential use within-licks and between licks. The four month seasonal use pattern can be divided into shorter periods when it is realized that each sex has its own pattern of use. This is termed differential use in time and implies that certain factors are limiting male use to a specific time and female use to a specific time, within a lick.

The daily total of males and females at the Toby Creek lick was plotted through May, June and July as shown in Figures 14, 15 and 16. The great fluctuations in numbers from day to day were caused by animals moving into and out of the lick synchronously with weather changes. Licks at lower elevations were used by males in late April and early May while those at higher elevations were not used until late May. During initial use, numbers were small but increased over the next 10 to 20 days.

From Figures 14, 15 and 16 showing daily numbers, cumulative totals were plotted for 10 day intervals from May to August, as shown in Figure 4. The peak for male use occurred around the end of May and for female use around the end of June or first part of July. The overlap of use by the sexes between May 30 and June 30 indicates the change-over

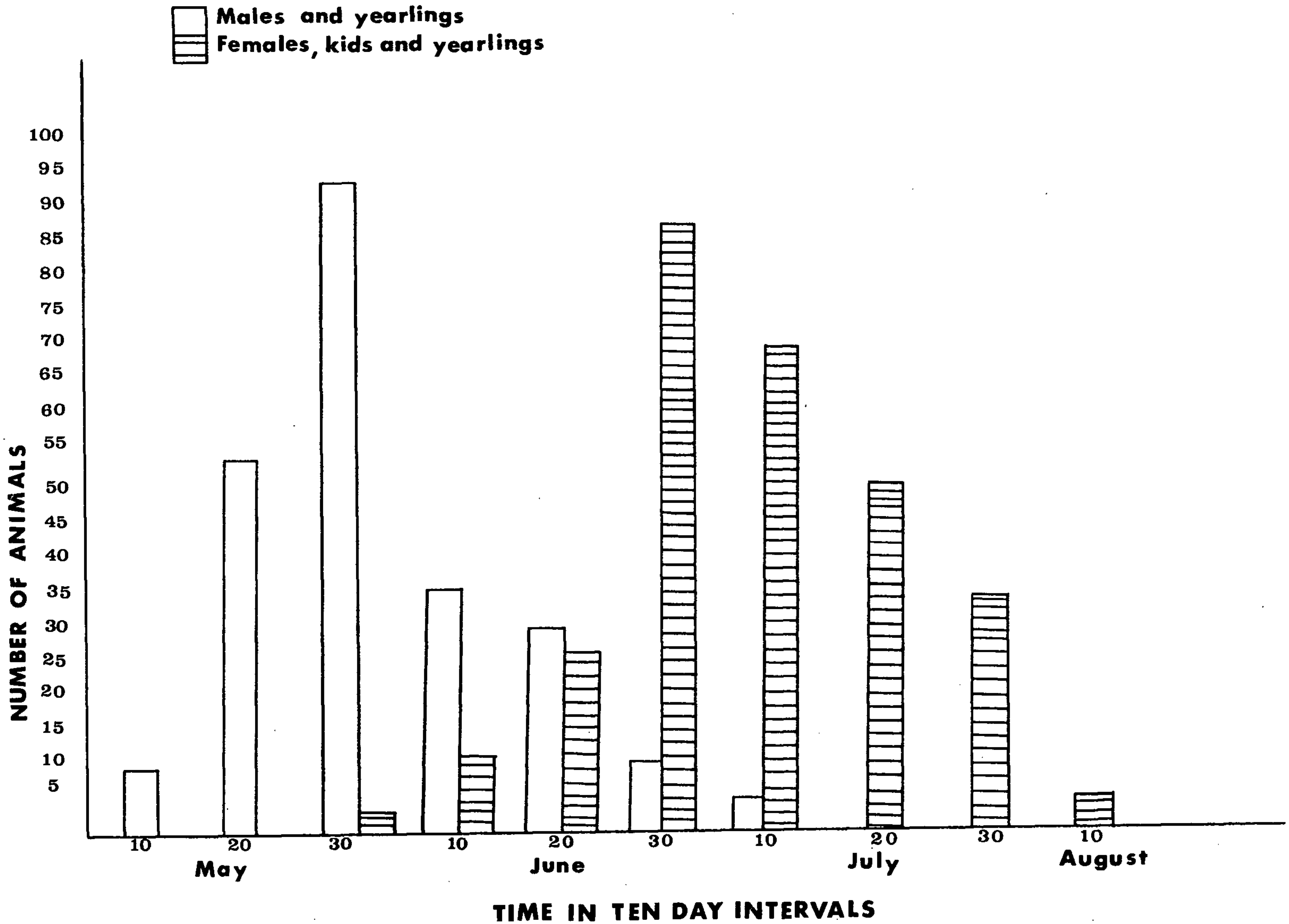

FIGURE 4. The cumulative totals for 10 day periods, at the Toby Creek lick, showing differential use in time.

from male to female use. The change occurred gradually; numbers of both sexes were reduced and the majority of females entering the lick had kids with them.

The cumulative totals of males and females are similar but after the peak, female numbers did not drop as fast as male numbers. The peaks reach approximately the same height and the buildup in both sexes took about 20 days. Male use occurred between May 1 and July 10, a period of 71 days and female use lasted for about 70 days. Total use was approximately equal for males and females but intensity of use by each sex as a whole could not be measured. Individual males and females could not be compared as to the degree of actual licking taking place. If the animals are attempting to satisfy a physiological deficiency then it would seem that the same time at the lick serves to satisfy each sex, regardless of differences in the physiological state.

Comparing Figures 5 and 6 shows the relation of kidding to changeover of use by sex. As female numbers increase in June so do kid numbers. The fluctuations in female numbers in Figure 5 closely parallel those in kid numbers shown in Figure 6. This suggests that females were restricted from using the lick due to kidding. Very few (2 or 3) females without young were in the lick prior to the influx of females with young. This appears reasonable, since females without

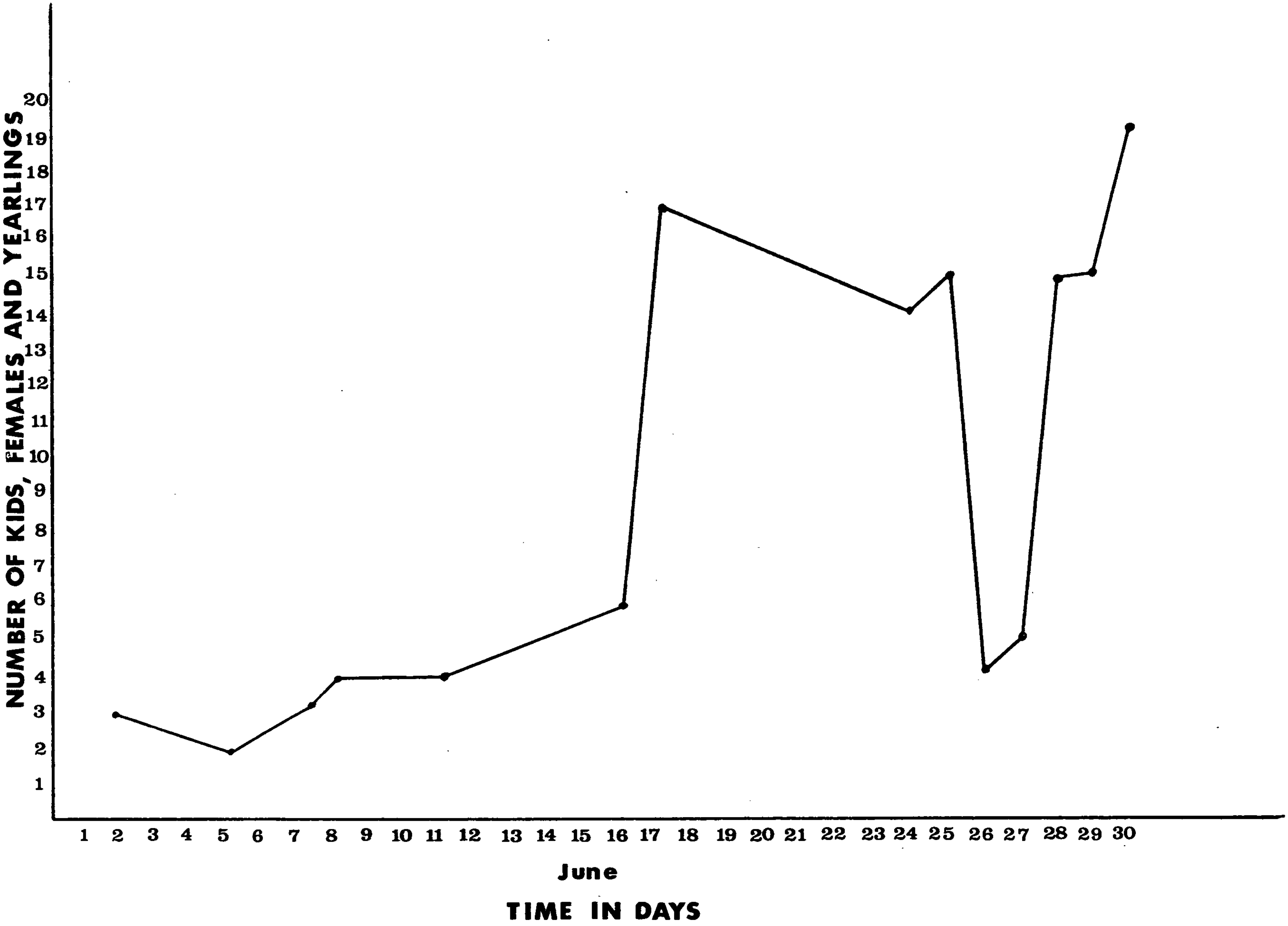

FIGURE 5. The increase in female use of licks during June, after the kidding period.

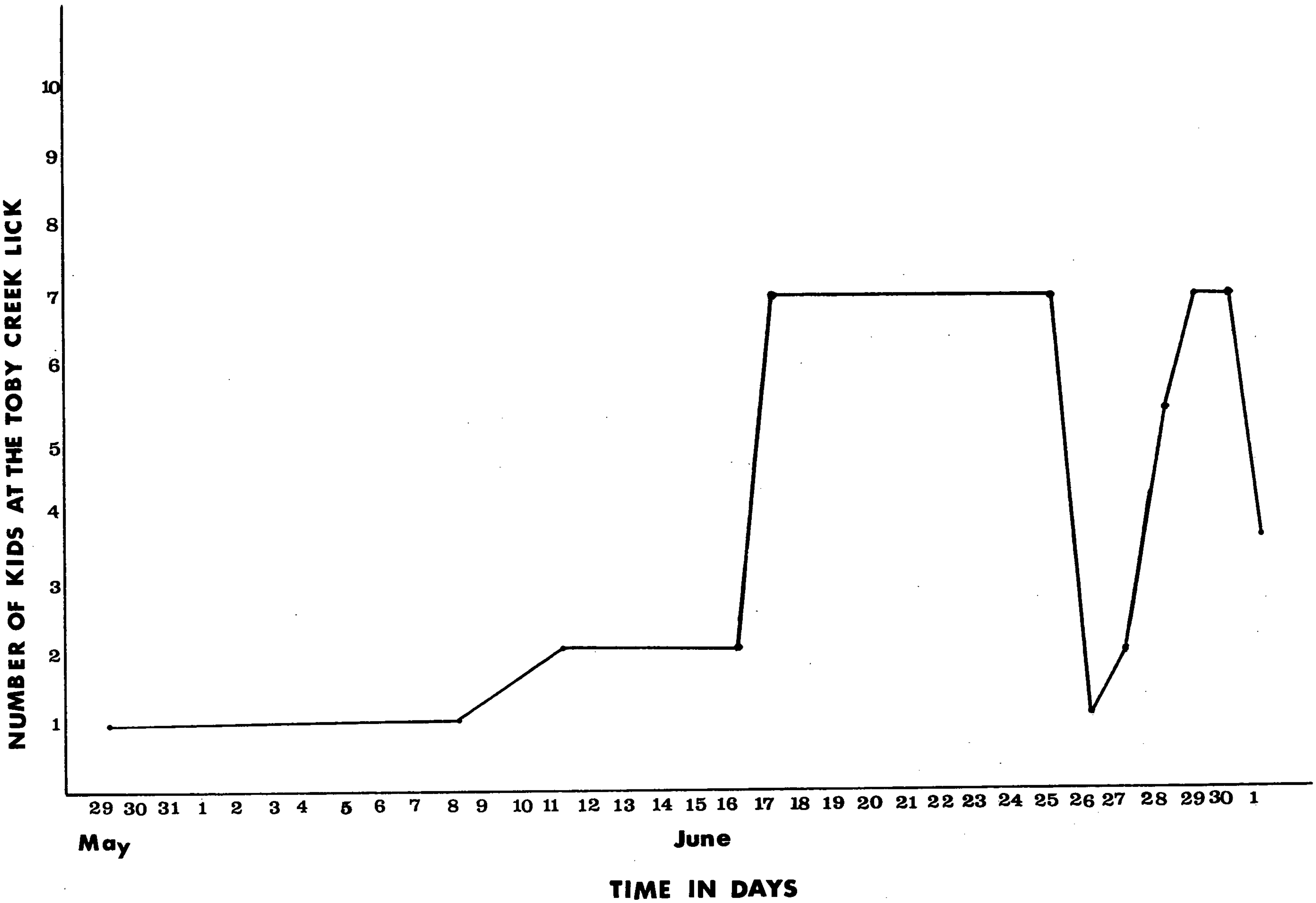

FIGURE 6. The increase in number of kids at the Toby Creek lick in June.

young were associated with females with young as an integral part of the family group and very seldom travelled alone. Behavioural factors rather than kidding would appear to restrict these animals from using the lick. Females with and without young moved into the lick in groups after kidding. Brandborg (1955) suggests that there is a rapid increase in the average group size as the kidding period progresses.

It may be that differential use serves to reduce antagonism between the sexes during kidding. Brandborg (1955) suggests that no tendency was observed for the nannies with kids to join billies in the formation of close family groups after the kidding period. At this time the female becomes aggressive toward the male and protects her young. Differential use may be an effective means of separating the aggressive female from the non-aggressive male.

Differential use as a general trend

It has been shown that differential use in time, as it occurs at the Toby Creek lick is a within-lick event, not to be confused with separation of the sexes between licks, which is to be explained. The separation of the sexes at this lick is definite. As a trend that can be applied to other licks, it appears that distance and the complexity of the lick, in terms of habitat features, have a modifying influence.

The data shown in Figures 7, 8 and 9 suggest that

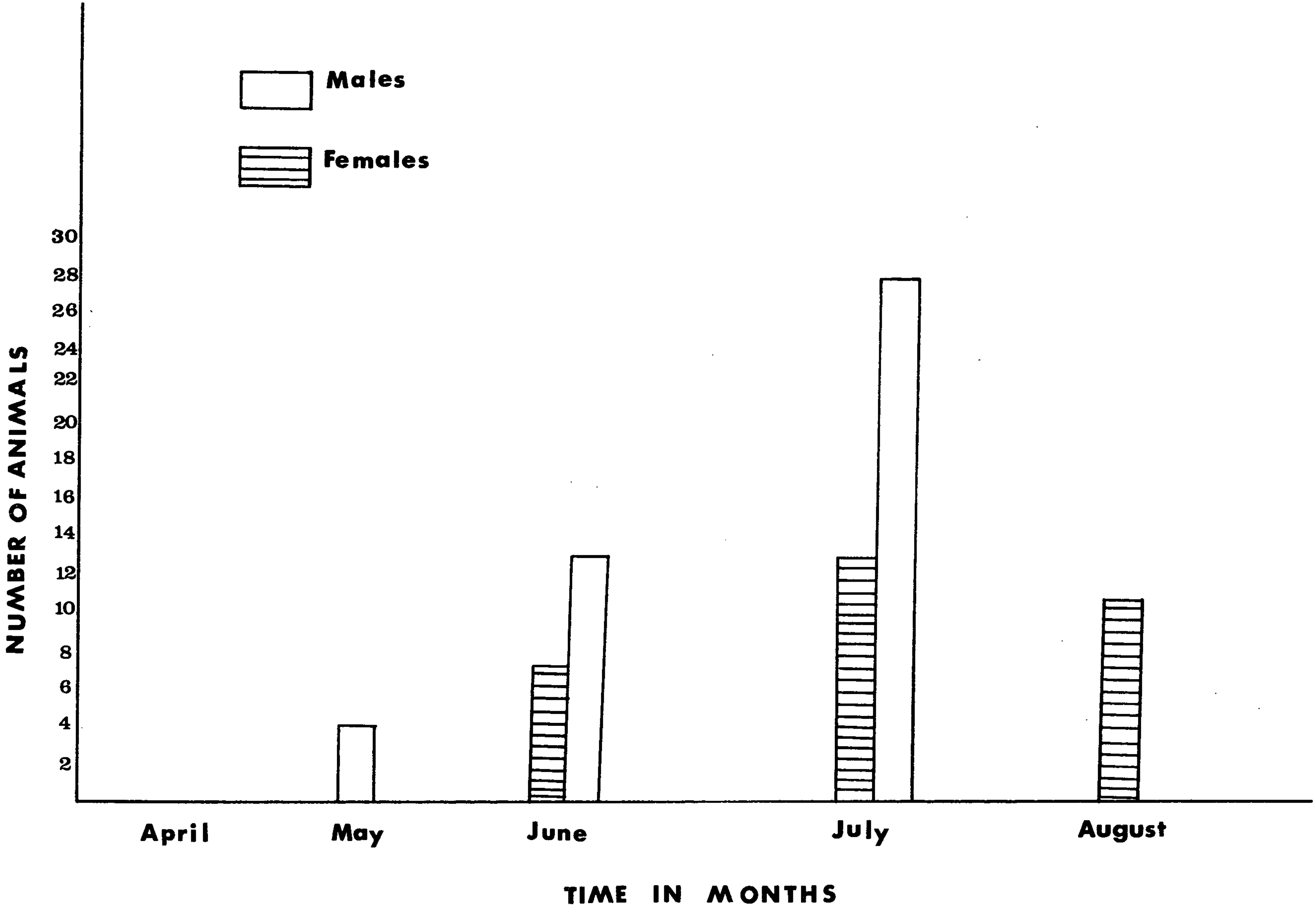

FIGURE 7. Differential use in time at the Dutch Creek lick.

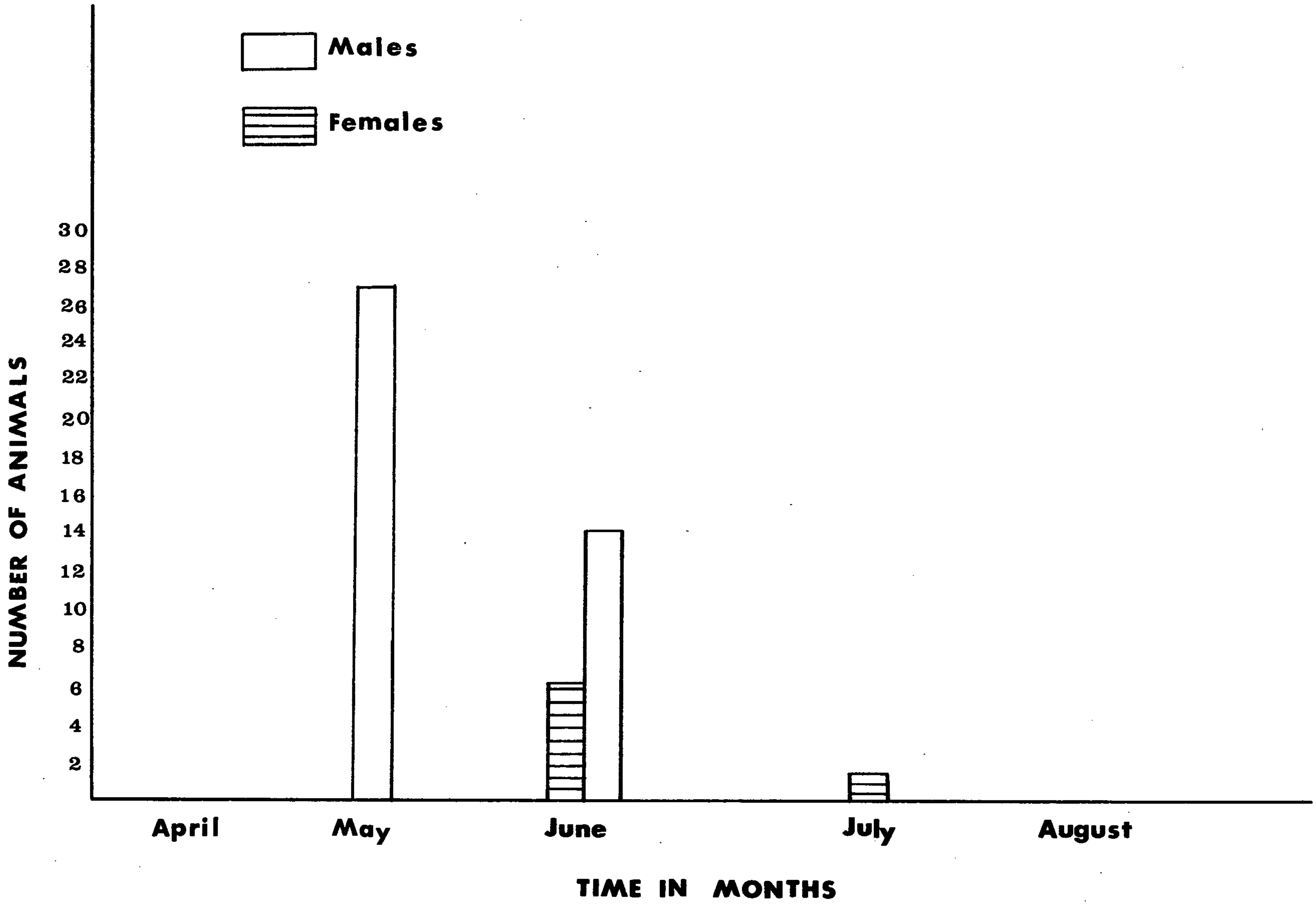

FIGURE 8. Differential use in time at the Stoddart Creek lick.

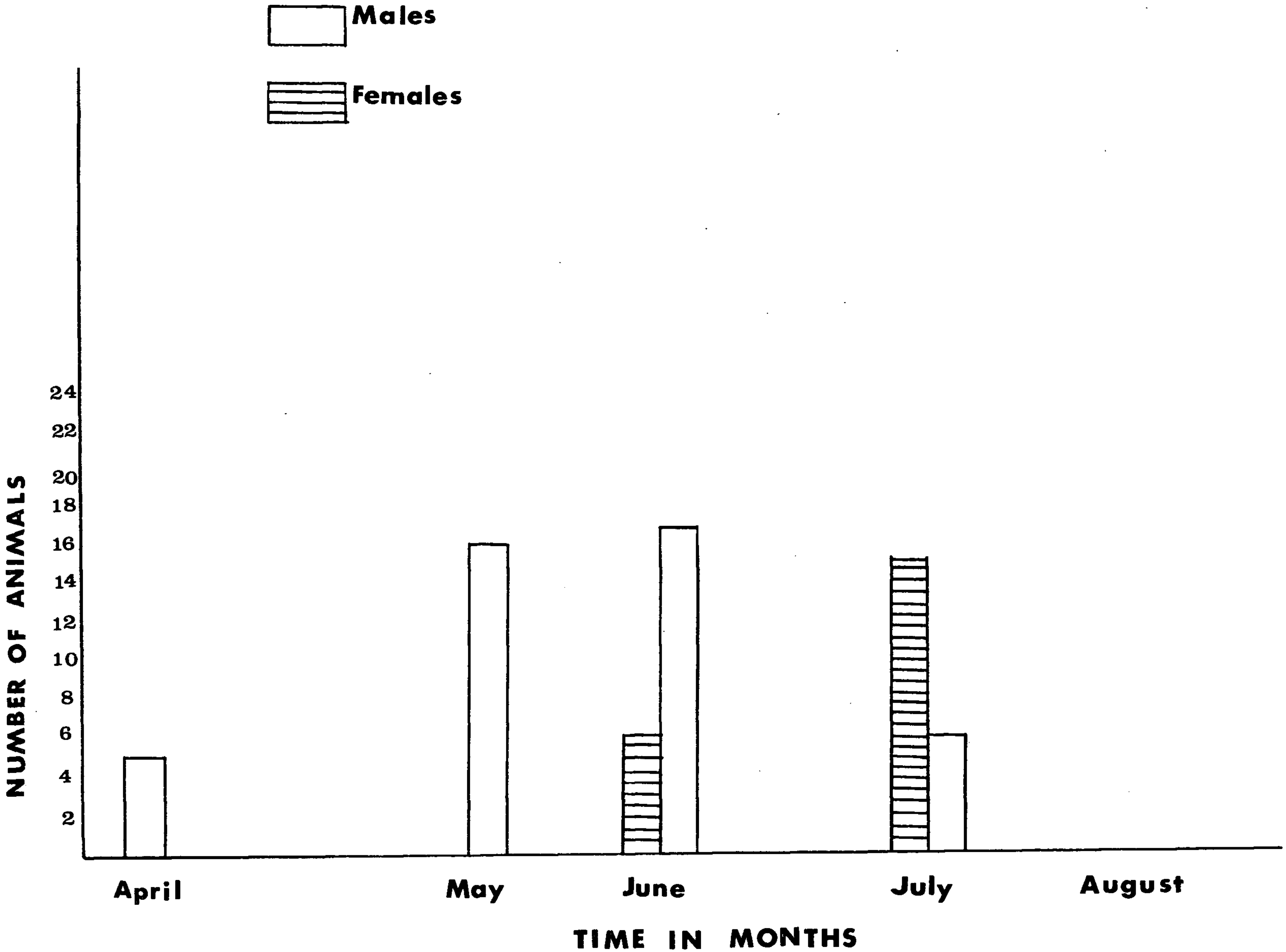

FIGURE 9. Differential use in time at the Lazy Lake lick.

differential use in time occurs at the Dutch Creek, Stoddart Creek and Lazy Lake licks. The overlap of use by the two sexes occurs in June; with males observed in the spring and mainly females in July and August. As will be shown, the short distances travelled at the Lazy Lake lick tend to promote daily trips so that male use extends into the summer and somewhat obscures the results. In general, it may be assumed that differential use probably is present to some degree at all licks in the study area.

Of the four licks having sufficient quantitative data to show differential use, three are at low elevations and one at a higher elevation. Use of the high elevation lick (Dutch Creek) begins later in the spring and ends later in the fall. The peaks of male and female use have shifted to later in the summer with use by females still occurring near the end of August. Use of the low elevation licks begins earlier in the spring and ends earlier in the summer. The pattern of differential use is similar at each lick yet the peaks can shift depending on the elevation.

Differential use between licks

The separation of the sexes in time, within a lick, has been shown but the possibility exists that the sexes could be separated by using different licks.

During the summer of 1965, young were not seen in the Mary Creek lick although males and yearlings were identified. Observations from the summer of 1966 showed females with young to be using the lick. None of the licks examined in the study area appeared to serve one sex exclusively.

Differential use in time as a within-licks phenomenon is present at the licks in the study area but as a between licks phenomenon, differential use appears to be nonexistent.

The differential effect of parasites, joint use, predators and hunter kill

Since differential use may be considered a general trend in lick use, it is apparent that the above factors will affect the sexes unequally. The male is susceptible to high external parasite loads and is affected by joint use since it descends to the valley bottoms in early spring. The female does not enter this region until other ungulate populations have migrated to higher elevations and the heat of summer has reduced the tick populations. Both sexes come into contact with a wider variety of predators present in this region. It is possible that the greater variety and number of predators could increase the mortality rate. Cowan and Brink (1949) report that almost all goat kills have been found adjacent to licks. In the study area predator control has probably reduced the importance of this factor. Females with young tend to remain at the licks later in the fall, making them more vulnerable to hunters. The degree to which each of these factors reduces the population in this area is not known.

GROUP SIZE IN THE LICK AS INFLUENCED BY DIFFERENTIAL USE

Males and females using the lick at different times during the summer showed a pattern of grouping that was consistent with their behaviour. The fact that males and females are very rarely seen together except during the rutting period and that yearlings are spurned by their mothers in the spring are traits influencing patterns of grouping. Although licks served to concentrate aggregations of animals, groups remained small with male groups smaller than female groups.

Etkin (1964), differentiates between groups and aggregations by saying that groups are social because the members stay together as a result of their responses to one another rather than by responses to the other factors in their environment. He suggests that where it is impossible to decide because of lack of evidence, whether a group is truly social or not, the noncommittal term "group" may be used.

In this study, group size was calculated from those animals seen in the lick and those moving between region 2 and the lick. An attempt was made to ascertain social groups but with males the noncommittal term "group" is probably more appropriate. Female family groups were usually considered social since they remained a basic unit. The female family group contains a female and a kid, usually one yearling and often a female without a kid. Since we are considering groups rather than aggregations it seems appropriate to include kids in the calculation of female groups, in order to show a difference between male and female groups. Yearlings were also included in the calculation of group size although it was almost impossible to differentiate sex. In only one instance were yearlings sexed. Two yearlings entered the lick with a group of 3 females and 3 kids and one female without a kid. One yearling was male and one female. It is not to be concluded that when females with newborn young chase yearlings away, that male yearlings enter male groups and female yearlings enter female family groups. Observations showed that the number of yearlings, regardless of sex, were approximately equally divided between adult male and female groups.

In defining a group as such, we hope to show that we are really dealing with group size rather than numbers and in this way can differentiate a group from an aggregation of any number of separate animals all on the lick at once.

Group size was calculated as average total group size per month, as well as each sex determined separately.

Total group size

The average total group size is shown in Figure 10. It shows a steady increase from April to July with the greatest increase between June and July. This increase in

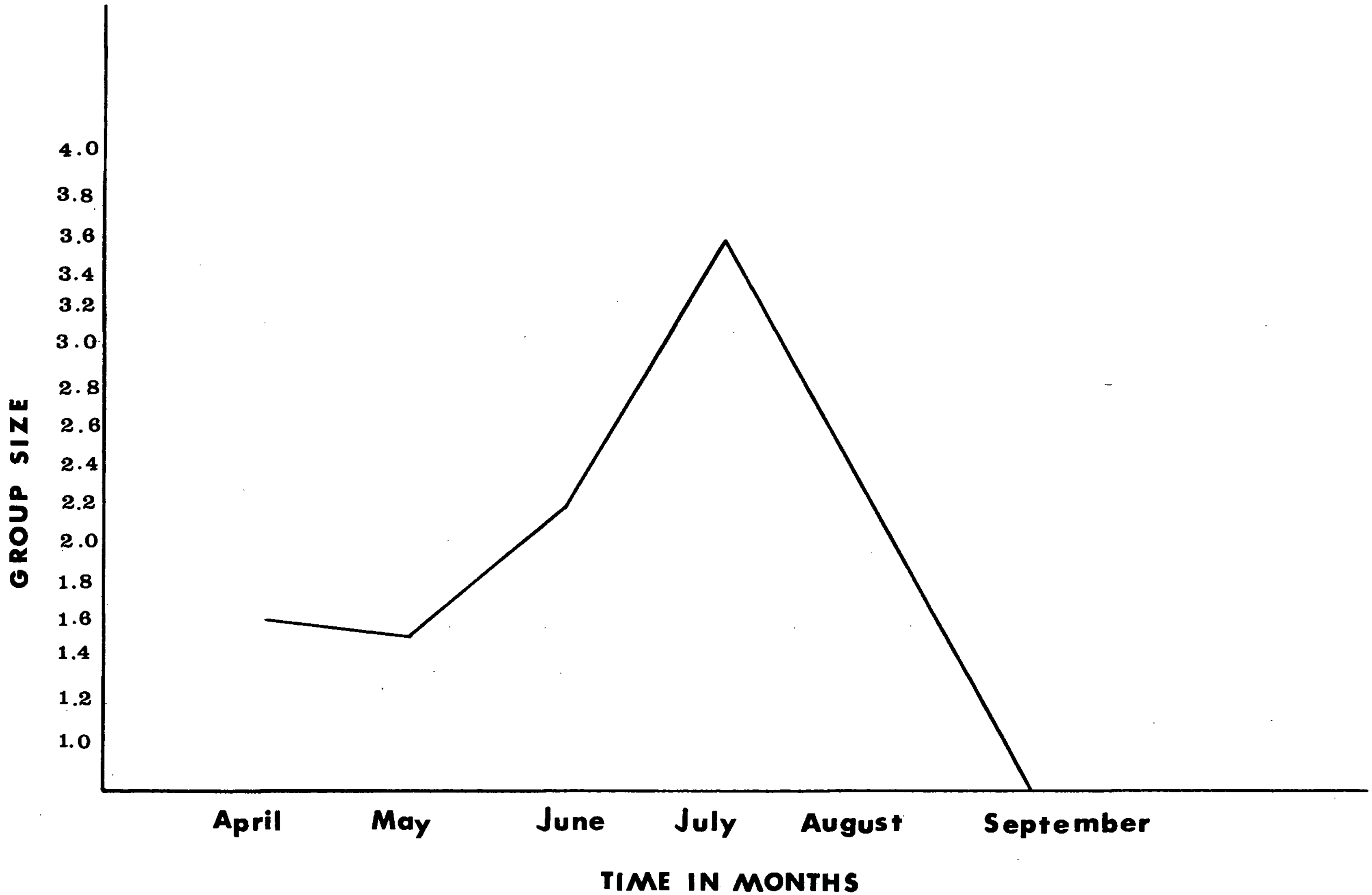

FIGURE 10. The average total group size (all sex and age categories) per month, using observations from all licks.

July probably represents the changeover to female use, with the female family group becoming prevalent. The April results are based on a limited number of observations but a total of 243 observations was used to determine average monthly values. The decrease in average group size between July and September is probably the result of large groups returning to the summer range, leaving individual family groups or females with young.

Male group size

The average group size for males, as shown in Figure 11, was calculated from 152 observations. Male group size was greatest in April and May but decreased from June to July. It appears that when males are concentrated in region 2, in the spring, group size is larger than in June when the male numbers are reduced. This would suggest that we have aggregations in the spring due to crowding. Since males and females are present in region 2 from June to July, crowding would also be present, yet it is at this time that male group size is reduced. Observations showed that males did not attempt to join female family groups. It may be possible that male group size is a function of the number of males present in an area regardless of the presence of females. Brandborg (1955) suggests that larger group sizes on the Red Butte ranges (7.5 and 6.1 animals per group for July and August) may be attributed to the greater population density on this range.

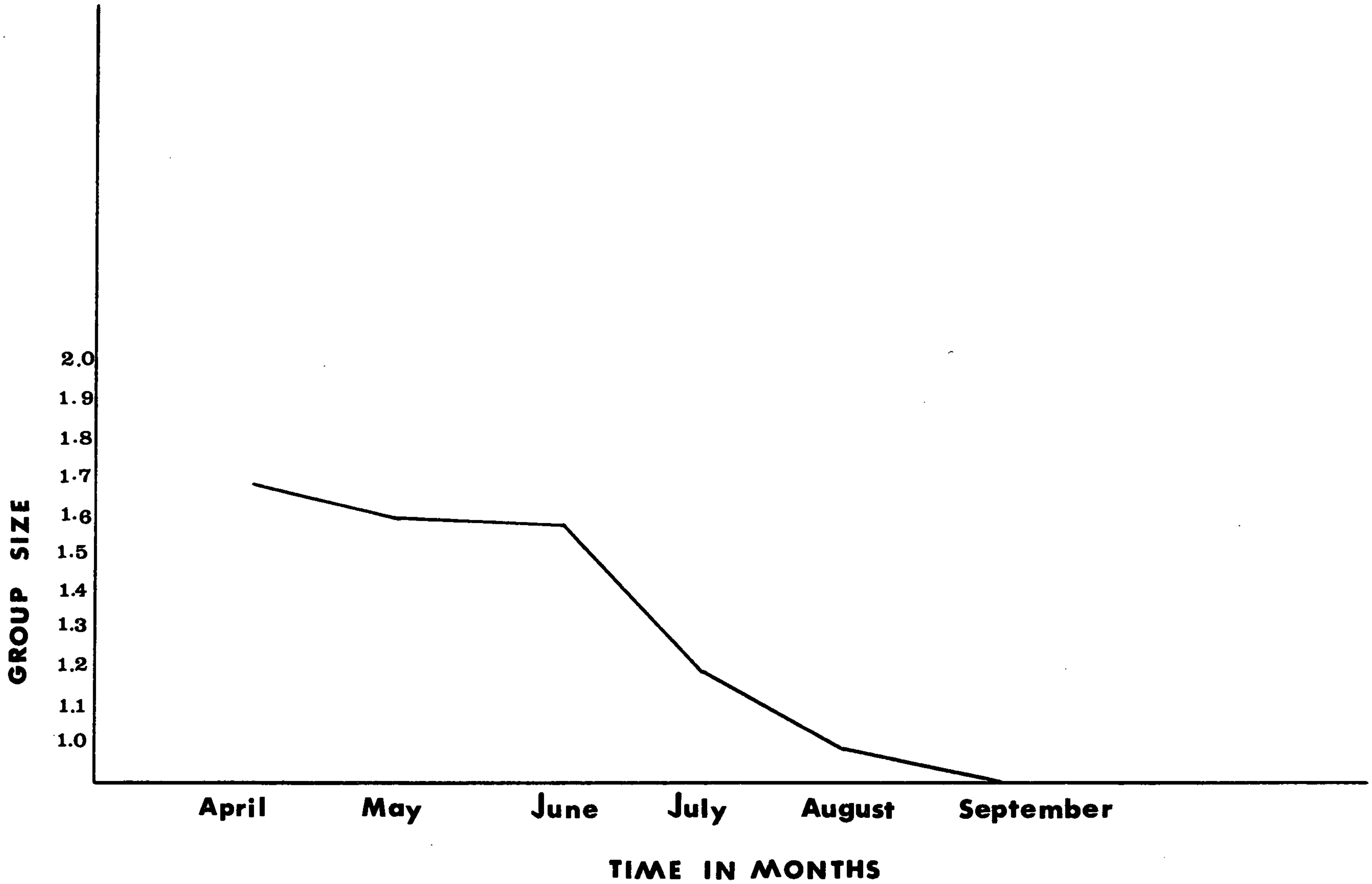

FIGURE 11. The average group size for males (all age categories) per month, using observations from all licks.

Female group size

The average female group size, as shown in Figure 12, was calculated from approximately 91 observations. The largest group size is in July and represents intensive use by the female family group. The increase in group size from June to July is attributed to the increase of family groups and units of family groups. In May, limited observations may bias this figure. Female groups first to enter the lick and those last to leave were usually single family groups or females with kids, thus indicating a reduced group size at the time. It is known that the peak of reproduction in most ungulate populations in this region occurs during a 2 to 3 week period in the spring. Fewer females have young before and after the peak than during it. As stated, single family groups were most prevalent during initial lick use and again when lick use terminated. The gradual increase, peak and gradual decrease seen during reproduction is similar to that of female use of the licks and may serve to explain reduced group size during early and late lick use. The evidence is strong that females that are to have young do not come to the lick until after these are born. The reluctance of the pregnant females to leave their normal range until after parturition, taken along with the cohesion of female groups no doubt explains the failure of even those females that lack young to come to the

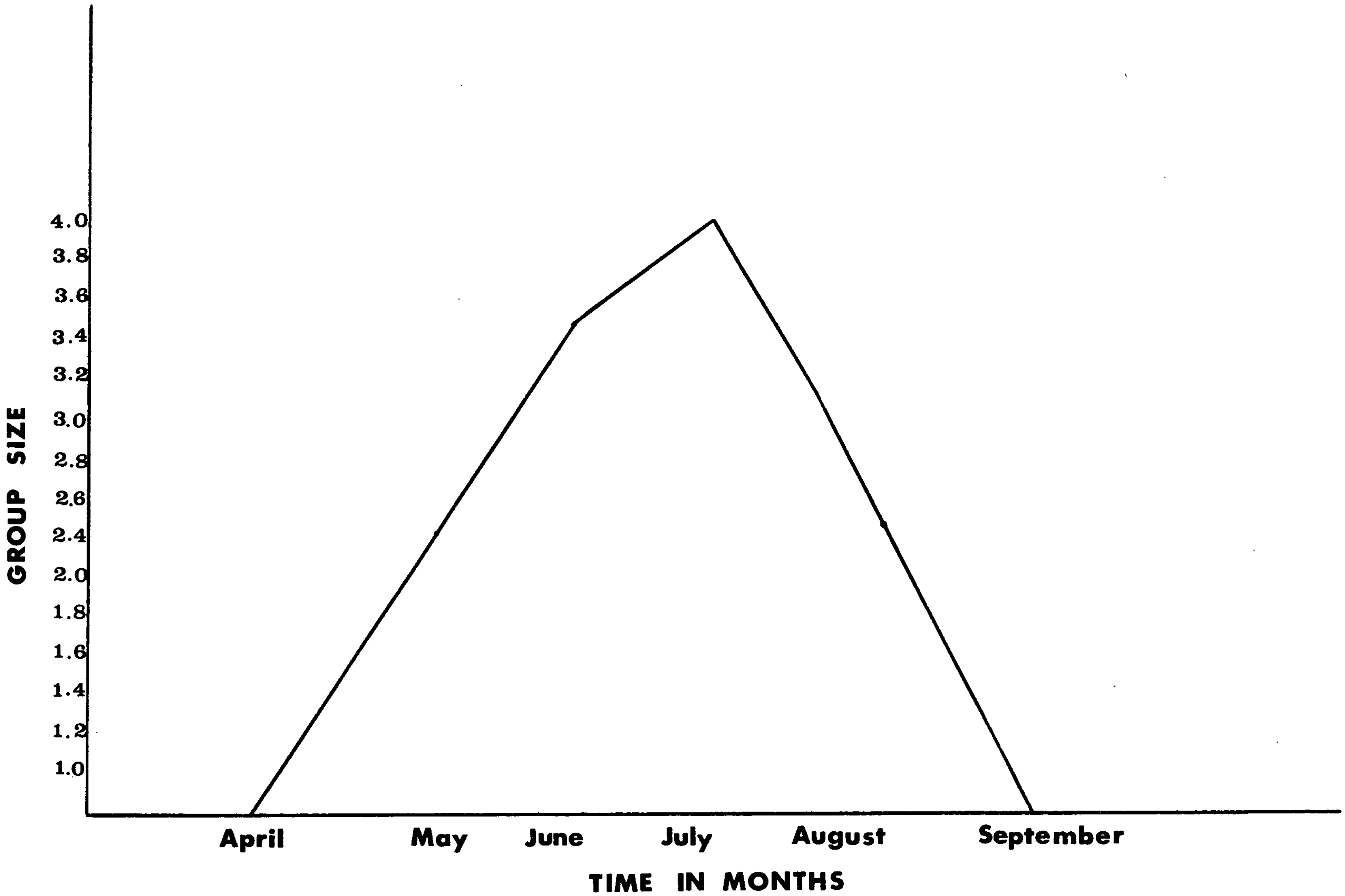

FIGURE 12. The average group size for females (all age categories) per month, using observations from all licks.

licks earlier.

The total average group size at the lick during June, July and August is comparable to that observed by Brandborg on alpine ranges, as shown in Table 1. The female average group size more closely approximates his data. The reduction in group size during May and August may be the result of a reduction in density and may not clearly represent the true group size. It appears that lick use does not appreciably alter the group size as the animals move between the lick and their summer range.

In only two instances were males seen closely associated with female groups in the licks. It is thought that they were not part of the group but represented an aggregation, since the males separated from the group at the slightest disturbance. As stated earlier, Brandborg (1955) suggests that there is no tendency for the nannies with kids to join billies, as suggested by Andersen (1940). The occasional occurrence of males in mixed groups during the spring and summer indicates that they do not lead an entirely solitary existence.

The aggregations of males, observed feeding in region 2, were highly unstable. Several instances were observed where four or five males were feeding or moving about on the same cliff. The aggregation did not exhibit any social ties among animals. Other males could enter this situation and some in the aggregation leave, causing a complete change.

Yearlings were observed in female family groups and with males in the spring. It is believed that females abandon yearlings to have young of the year. Observations during the summer of 1966 showed that females with young are antagonistic toward yearlings and in many cases force independence upon them. Throughout the summer, yearlings are chased by the females whenever they wander close to a kid, however, their drive to associate with their parent is sufficiently strong that they frequently follow along behind the nanny and kid. Yearlings are also chased by other adults since they are subordinate. About half the yearlings seen were with females with young, showing that the female is not always successful in chasing them away. The shift of the yearling from female to male groups and the factors affecting it, are not known. Yearlings with adult males tend to increase the average male group size.

Table 1 A monthly comparison of average group size, using data from Brandborg (1955) and data from the East Kootenay region.

Month	Range	Average Group Size		Range	Total Group Size	Female Group Size
May	Salmon River	2.7	-	Toby Creek	1.6	2
	Red Butte	3.5	- 2.9			
	Bitterroot River	2.6	-			
June	Salmon River	3.6	-	Toby Creek	2.3	3.2
	Red Butte	3.3	- 3.4			
	Selkirk	3.4	-			
July	Selkirk	3.6	-	Toby Creek	3.7	4
	Red Butte	7.5	- 5.2			
	Selway River	3.8	-			
	Teton River	6.1	-			
August	Salmon River	3.0	-	Toby Creek	2.3	2.3
	Red Butte	6.1	- 3.9			
	Selway River	2.8	-			

BEHAVIOUR

During the two summers of field work certain aspects of goat behaviour, regarding the use of licks, was thought to be important.

In region 2, aggregations of males were continually changing in makeup as new aggregations entered the region and others left. When two aggregations met, goats moved from one to the other freely but at no time was antagonism observed. When males were in the lick, adults were not observed to displace one another from preferred licking sites, although yearlings were constantly chased from these sites.

Males and females used the licks at different times during the summer, however one male - female encounter was observed at the Lazy Lake lick. At this time the female chased the male off the trail and made it detour widely. The male was much larger than the female but did not retaliate when the female charged.

Female encounters were common in region 2 and most licks in the study area. On June 7, 9 goats were observed in the Dutch Creek lick. There were 3 females with kids, 1 female without a kid and 2 yearlings. The majority of licking activity occurred on the high licking sites with females with kids displacing females without kids and yearlings. Females without kids could displace yearlings. Among the females with kids it appeared that size played a major role in determining which female was dominant. Although size was determined by observation only, the supposedly larger females could always displace a smaller one from a preferred lick site. Aggressive activity consisted of the dominant female making one or two hops, with head lowered, toward the smaller female. The aggressor would bring its head up in a horn thrust on the last hop but contact was not observed. Within the female family group, the same order of dominance prevailed: females with young, females without young and yearlings. This type of hierarchy would benefit females with young by allowing them preferred sites in the lick.

In region 2, females often met on the main trail as they moved to and from the lick. No evident relation appeared to exist between those occupying a site on the trail and those showing dominance. Animals lying on the trail displaced approaching animals as often as they were displaced. The size of a group approaching or occupying a site did not seem to matter as far as dominance was concerned. In one case, a female and kid approached a group of 5 goats lying on a trail and chased them off so they could get by. The group consisted of a female with a kid, a female without a kid and 2 yearlings. Again it appeared that size of the individual animal was the determining factor.

DIFFERENTIAL USE AND ITS EFFECTS ON MOLT

The patterns of seasonal and differential use of licks as a part of the ecology of the goat show a definite effect on the rate of molt. This is evident when we note the termination of molt in males, females without young and females with young. The habitat conditions and the time each class of animals spends in these conditions greatly affects the loss of hair. Cowan (1940) describing the molt in sheep, reports that, "Individuals inhabiting areas where there is some brushy cover tend to molt the old hair on the sides and abdomen early as a result of the rubbing of these parts on the bushes". Cowan (op. cit.) further states that, "As in many, if not all ungulates, physical condition undoubtedly affects time of molt. Mature rams on the average molt earlier than ewes with young or animals of either sex in poor condition." It is not known whether the physiological mechanisms involved in molt induce molt at the same time in each class of animal but the following discussion describes the influence of the lick on the pattern and termination of molt.

By the end of May, males had lost patches of hair on their nose, throat and chest region including the top inside part of their front legs. Hair had also been lost from the rest of the body, causing a thinning effect but no patchiness was evident in the posterior region. The physiological process of molt had begun in the males but the rapidity with which they lose their hair results from the abrasion of the pelage by the shrubby terrain in which they are living.

Towards the end of June, males had lost approximately one-half of the old coat and the remaining portion was extremely thin and ragged. The molt moves from anterior to posterior. The front quarters and lower portion of the abdomen are completely bare at this time while the hind quarters and upper portion of the abdomen still retain the old coat.

The females without young have lost approximately 25 percent of their old coat toward the end of June. This is in the anterior region, with the sequence the same as for males. Females had just begun to use the lick and abrasion by the vegetation had continued for a shorter time.

In July, the males and females without young lose the remaining portion of their old coat; with males losing theirs first. Both had completed molt by the 15th to 20th of July. At the end of July their new coat was ½ to 1 inch in length. Brandborg (1955) observing goats on alpine ranges states, "of 10 animals observed at close range on July 14 near Red Butte, only one adult male had shed the old hair completely." It appears then that abrasion may hasten molt.

The females with young lose their old coat much more slowly than males or females without young. The females with young have spent the same length of time in the vicinity of the lick as females without young but have retained much more of their old coat. Most animals have completed molt by the end of August. The pattern of molt for these three categories is shown in Figure 13. Although abrasion aids in hair removal, the over-all pattern is fixed by physiological processes.

Similarly, differential use of licks, in time, leads to use of dust baths by males and not by females. Males arriving at the lick in early spring are molting and become more susceptible to attack by the paralysis tick. The animals would sit on their haunches and kick dirt onto their body with their front feet. Geist (1964) describes this action in the adult male during rut, by saying: "Adult males were soon easily distinguished from females by black patches of dirt on the rump, as well as by streaked flanks, matted "trousers" and dirty bellies. These they received from pawing rutting pits, a behavior associated mainly with aggression, but which could appear in courtship or spontaneously."

It seems quite possible that this is the same behavioural stance which is being used to achieve another end. The aggressive tendencies shown by the head and body position are absent. It was thought that males may dig these pits in order to lie on the cooler earth. Since females were in the lick during the hottest part of the summer and did not use the

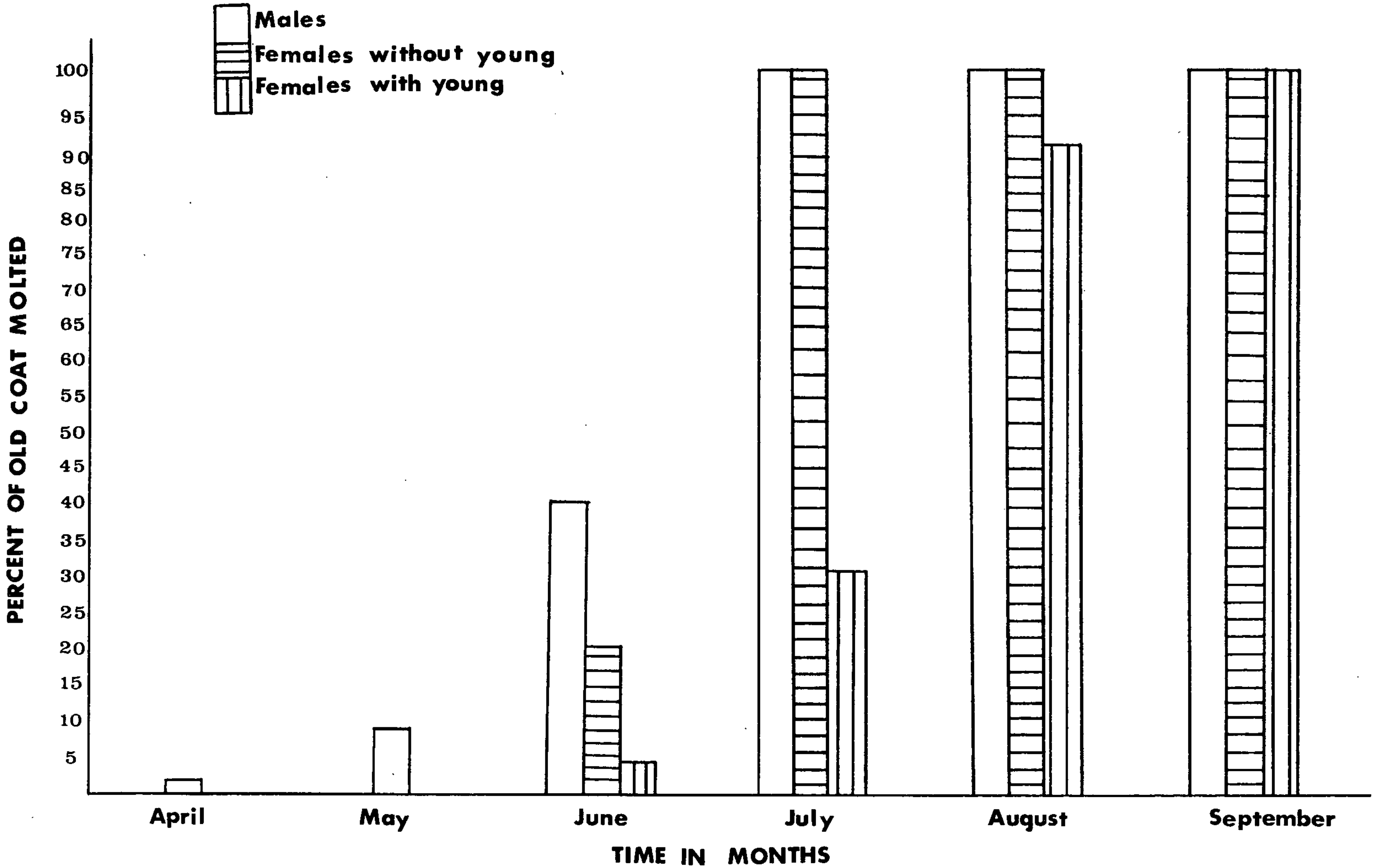

FIGURE 13. The sequence of molt, caused by abrasion from vegetation, while the animals are using the lick.

dust baths, this did not seem the logical answer. Females entered the lick after the tick infestation and so dust baths were thought to be used by the males, to reduce irritation caused by ticks.

LICK USE OVER A 24 HOUR PERIOD

Intensive lick use occurred at different times of the day at different licks, depending on the structure of the lick. A comparison of the Lazy Lake, Dutch Creek and Toby Creek licks serves to illustrate the differences.

As shown in Table 2 intensive lick use at both the Dutch Creek and Lazy Lake licks occurred in the afternoon.

Table 2 Periodicity of daily use at the Lazy Lake and Dutch Creek licks, based on observations of groups.

Lick	No. of Groups	Morning 0/0	Afternoon 0/0	Evening 0/0
Lazy Lake	30	0	83	17
Dutch Creek	21	0	67	33

The goats did not use the lick in the morning but some use occurred in the evening. These two licks have been described as simple licks having few habitat features common to region 1. This results in a periodicity of use not seen in more complex licks. The fact that more licking was done in the evening at the Dutch Creek lick can probably be attributed to the short distance between region 2 and the lick. At Dutch Creek, large groups (9-15) used the lick mainly in the afternoon with individual animals entering in the evening. At Toby Creek, intensive lick use showed less restriction to the afternoon.

Animals were observed licking in the morning, evening and afternoon, although the majority of use still occurred in the afternoon. This is considered the most complex lick and animals would spend from 2 to 4 days in the lick at one time. Since the animals could feed and move about the lick from dawn till dark, lick use was not restricted to any one period of the day. The number of habitat features, then, plays an important role in concentrating lick use during the daylight hours.

SEQUENCE OF LICK USE DURING THE SUMMER

It has previously been shown that males entering region 2 in April and May utilize succulent forage before entering the lick. As the summer progresses, animals feed at successively higher elevations so that they are continually feeding on young forage while using the lick. As shown in Table 3 animals in the vicinity of the lick were categorized as to whether or not they were in the lick.

During April, males were not observed in the lick and almost all observations showed them to be feeding. As the summer progressed and the distance between succulent forage and the lick increased, animals were more frequently observed licking once they reached the vicinity of the lick. Males, in the vicinity of the lick in spring, were there for two reasons; to feed on spring forage and to use the lick. Males were observed using the lick more frequently as the time spent feeding on succulent forage increased. Females, feeding in region 1 and the higher portions of region 2, upon entering the vicinity of the lick in June and July were more often observed in the lick as this was their primary reason for being at this low elevation. It appears that as the cumulative time animals had been feeding on succulent forage increases and as the distance between succulent forage and the lick increases, lick use increases. This is shown by the observation that in June and

July animals were more frequently seen in the lick than merely in the vicinity (Table 3).

Upon examining Tables 2 and 3 it is seen that lick use was greatest in the afternoon and most intensive in July. It was during July of both summers that the temperature was highest and number of storms reduced. These statements will be examined in more detail in a later section.

As lick use increased over the summer it must be remembered that group size also increased. Increase in lick use may be a function of the larger groups being more visible.

Table 3 Change in degree of lick use, using combined group observations from the Dutch Creek and Lazy Lake licks.

Month	No. of Groups	In the Lick 0/0	Not in the Lick 0/0
April	4	0	100
May	8	12.5	87.5
June	21	28	72
July	20	80	20

DISTANCE AS IT RELATES TO LENGTH OF TIME SPENT IN THE LICK

Distance seems to be important in determining the amount of time spent in the lick at any one visit. This can best be shown by comparing the Lazy Lake lick to the Dutch Creek lick. This is, in essence, a comparison of a lick where a short distance separates region 1 from the lick to one where a much longer distance separates region 1 from the lick.

At Lazy Lake, observations show that reduced amounts of time were spent in the lick regardless of the time of day licking occurred. Most observations were of female groups and the average time was 2 hours. It appears that the accessibility of the lick has reduced the amount of time spent in the lick although it is likely that frequent trips may offset this.

At Dutch Creek, the average amount of time spent in the lick is about 5 hours as shown in Table 4.

Table 4 The average time spent in the Lazy Lake and Dutch Creek licks based on observations of female groups.

Lick	No. of Observations	Average Time In the Lick (hr.)
Lazy Lake	9	2
Dutch Creek	13	5

Again most observations are of female groups so the comparison is valid. In the spring, males were moving between region 2 and the lick and spent very short periods in the lick, much the same as at the Lazy Lake lick. In general, it seems that animals which travel long distances to reach a lick travel in larger groups, are regular in their timing and spend longer periods in the lick at any one time. The reverse is true of situations where short distances prevail between region 1 and the lick.

Complexity of the lick

Although distance appears to be important in regulating group size, time of entry to the lick and amount of time spent in the lick, we must consider complexity of the lick as a regulating factor once the animals reach the lick. At Toby Creek, animals spend 2 to 4 days in the lick although the distance between region 2 and the lick is very short. While in this lick goats feed and bed much as they do on their summer range so that less time is spent actually licking. It appears that once in the lick, licking, feeding and bedding are of equal importance. The Dutch Creek lick has few habitat types and once the animals are in the lick, licking is of primary importance. Apart from occasional drinks and the odd departure from the lick to urinate and feed, most time is spent licking. The Lazy Lake lick has little feed in the lick and although some escape terrain is present goats did not appear to use it for bedding purposes. When goats were in this lick the majority of time was spent licking.

In conclusion, it may be said that although the definite use of trails increases the efficiency of movement between regions, distance and complexity of the lick regulate the movement.

PATTERNS OF FREQUENCY OF USE

It is believed that the frequency of use by an individual or group is largely determined by the nature of the factors initiating lick use. It has been postulated that succulent vegetation (Dalke et. al. 1965) and- or a dietary deficiency, (Cowan and Brink, 1949 and Honess and Frost, 1947) could lead to initiation of lick use. This suggests that if it is due solely to a winter dietary deficiency, the animals should enter the lick, satisfy the craving and leave. If it is due to a winter dietary deficiency plus a high water uptake on a low salt diet in the spring, the animals will probably make frequent trips to the lick. Since animals feed on succulent vegetation prior to using the lick, the effects of a winter dietary deficiency could not be determined. The initiation of lick use could only be related to the critical period in the spring.

In order to ascertain frequency and duration of use, a limited program of marking was undertaken at the Stoddart and Toby Creek licks. This was set up to allow us to describe patterns of movement, to assess the relative importance of region 2, to relate animal movement to temperature and storms, to deduce changes in the population and eventually give a population estimate.

A total of 20 animals was marked at the two licks and subsequently identified. Others were known to have been marked by our automatic marking devices but we were unable to confirm this by actual sightings. Marking was carried out in the lick for short periods during intensive lick use and was continued throughout the summer. The results of marking and subsequent sightings are shown in Table 5.

Duration

Within each major period of use by the sexes, an attempt was made to determine the duration of use by individuals. This would indicate whether populations using the lick changed in number and composition. The duration an individual spent in region 2 or 3 could not always be measured accurately, since the period animals were present prior to being marked could not always be determined. The time between the known marking and subsequent sighting is taken as the minimum time the animal was present in region 2 or 3. Intensive marking was accomplished during the early part of May, the latter part of June, and the latter part of July. The periods between marking were used to note changes in the population.

As shown in Table 5, animals marked in the lick in early May were present from 2 to 7 days in the lick or region 2. One animal marked on May 12 was present for 16 days but was not seen again after May 27. During the latter part of

Table 5 Marked animals and subsequent sightings at the Stoddart and Toby Creek licks.

	Animal	Date Marked In lick	Lick	Subsequent Sightings: Seen in lick	Subsequent Sightings: Seen away from lick	Period between Marking and Sighting
1.	Adult male	May 12	T		May 18	7
2.	Adult male	May 17	T		May 18	2
3.	Yearling	May 18	S		May 19	2
4.	Adult male	May 12	T		May 18-19-20-24-27	16
5.	Adult	May 17	S		May 22	6
6.	Adult male	May 27	T	May 24 & 27		6
7.	Adult male	May 23	T		May 25	3
8.	Yearling male	May 26	S	May 26		1
9.	Adult male	Between May 23-27	T	May 28	May 27-29	6
10.	Adult male	Between May 23-27	T	May 28	May 27-29	6
11.	Adult male	May 31	T	May 31		1
12.	Yearling	May 24	S		May 27	4
13.	Adult male	June 13	S	June 13		1
14.	Adult female	June 19	T	June 29 & 30		12
15.	Adult female	June 25	T	June 28		4
16.	Adult female	June 25-27	T		June 29	4
17.	Adult female	June 24	T	June 28-29	June 25-27-28	6
18.	Adult female	June 24	T		June 25	2
19.	Adult female	June 27	T		June 29	3
20.	Adult female	June 25	T	June 30		6

T = Toby Creek lick

S = Stoddart Creek lick

May, marked animals were present for periods of 1 to 6 days. During periods between marking and subsequent sightings, animals were thought to spend the majority of time in the timber and on the cliffs in region 2. Animals were more consistently observed in region 2, and on two occasions animals were observed in the lick on one particular day and in region 2 the days preceding and following it. In May, males spent much time feeding in region 2 and appeared to make frequent trips to the lick (tracks and shed hair) although sightings were not made to confirm this. During the latter part of June animals were present for 2 to 12 days as shown by marking and subsequent sightings. Marked females appeared to travel between region 2 and the lick less frequently than males and spent longer periods in the lick on any one visit than did males (tracks and shed hair).

Frequency and patterns of movement

The patterns and frequency of movement between regions 2 and 3 were extremely difficult to determine. Inadequate sightings prevented us from following in detail the movements of very many individual animals. Animal number 4, marked in the lick on May 12 was observed feeding in region 2 for three days (May 18, 19, 20). A storm between May 20 and 23 probably did not permit this animal to enter the lick but between May 24 and 27 it was thought to have entered the lick.

Adult male number 6 was marked on May 22 (in the lick) and was again observed in the lick on May 24 and 27. It was not observed in region 2 between these dates. Two males (numbers 9 and 10) marked in the lick around May 24 were sighted in region 2 on May 27, in the lick on May 28 and again in region 2 on May 29. They were together at all sightings. An adult female, marked on June 19 was observed in the lick on June 29 and 30. Between these dates its whereabouts were not known exactly but it was thought to be in region 1 or 2. Female number 17, marked in the lick on June 24, was seen in region 2 on June 25, 27 and 28 and in the lick on June 28 and 29.

It appears from these data that animals move between region 2 and 3 repeatedly during the period they are in the vicinity of the lick. They seem to spend considerable time in region 2 feeding, but make frequent trips to the lick. Animals were observed to frequent the lick on several occasions during short periods but definite patterns could not be established due to a lack of consistent sightings of marked animals.

The importance of region 2

The use of region 2 as a base from which goats move to use the licks was not realized until marked animals were consistently observed returning to this region. Earlier studies do not mention such an idea and it was at first believed that animals were passing directly between the alpine summer ranges and the lick, with short pauses along the way.

The subsequent sightings of marked animals is shown in Table 5. Males, in May, spent a considerable amount of time feeding in region 2 and while few sightings of these animals were made in the lick, tracks and shed hair on the trail leading to the lick attested to their frequent movement between the two regions. At intervals along the trail leading to the lick, tracks were brushed off each day and hair removed from branches. Certain branches were positioned to remove molting hair from animals entering or leaving the lick. In many cases, a marked animal which disappeared from region 2 was thought to be in the lick since marked hair was picked up on the trail, indicating that it had passed this spot and was headed for the lick. Males were not observed feeding around the lick and returned to region 2 to bed and dig dust baths. It appeared that region 2 was supplying males with all their habitat essentials and thus detracted from time spent in the lick.

When females entered the vicinity of the Toby Creek lick they fed in the highest portion of region 2. This increased the distance between the lick and area of intensive feeding. Females were more often observed feeding around the lick, bedding in the lick and seemed to spend more time in the lick on any one visit. It appeared that they moved less frequently between region 2 and the lick, as shown by tracks and shed hair. Similarly, at Dutch Creek, females made fewer trips between region 1 and the lick, did not utilize region 2 (the vegetation there had matured) and spent considerably longer periods in the lick at any one time, than did the males.

Region 2 appeared extremely important as long as it contained succulent vegetation and the distance between it and the lick was quite short.

Environmental factors affecting movement

Although mineral deficiencies and water content of the vegetation may determine over-all patterns of lick use, such environmental factors as temperature and weather may determine a more refined distribution of use during the summer. Daily temperature for July, 1965, was plotted as shown in Figure 17 and for May, June and July of 1966, as shown in Figures 14, 15, and 16. The daily readings were obtained from the Cranbrook Airport station in most cases but also from the Radium Junction station when available (Dept. of Transport, 1965 and 1966). Field climatic stations were not set up in this study as only the trends in temperature were needed and the readings from the two established stations were adequate. In general, the peaks in temperature, from 65°F. to 95°F. were warm and sunny with only the occasional thundershower. The lows in temperature, from 50°F. to 65°F. approximately, were usually cool, cloudy and often stormy. It rained often during the stormy periods. On the above listed figures, animal numbers were superimposed to show a correlation between temperature, weather and animal movement.

In July, 1965, animal numbers were recorded at the Dutch Creek lick. As shown in Figure 17, at least one large group of animals used the lick during each peak in temperature. Activity was greatest at this time and tracks showed that for 2 to 3 days during each peak, animals were moving in and out of the lick. Animals were observed to enter the lick during the hottest part of the afternoon and remain there for 6 to 8 hours, suggesting a strong correlation of lick use and temperature. During the lows, although dropping only to 65 F., storms were common and very few goats were observed. Activity in the vicinity of the lick was almost nil with only the odd individual animal moving about. The difference in activity in region 2 and 3 prior to a storm and during it, is shown in Table 7. Beeman (1957), states that in the lower Selway River area, rain storms may come quickly and last for days. Elk activity was noted to drop sharply during these rains.

The high degree of correlation achieved at the Dutch Creek lick in 1965 did not occur at the Toby Creek lick in 1966 as seen by comparing Figures 14, 15 and 16 to Figure 17. This was due mainly to the great difference in summers between

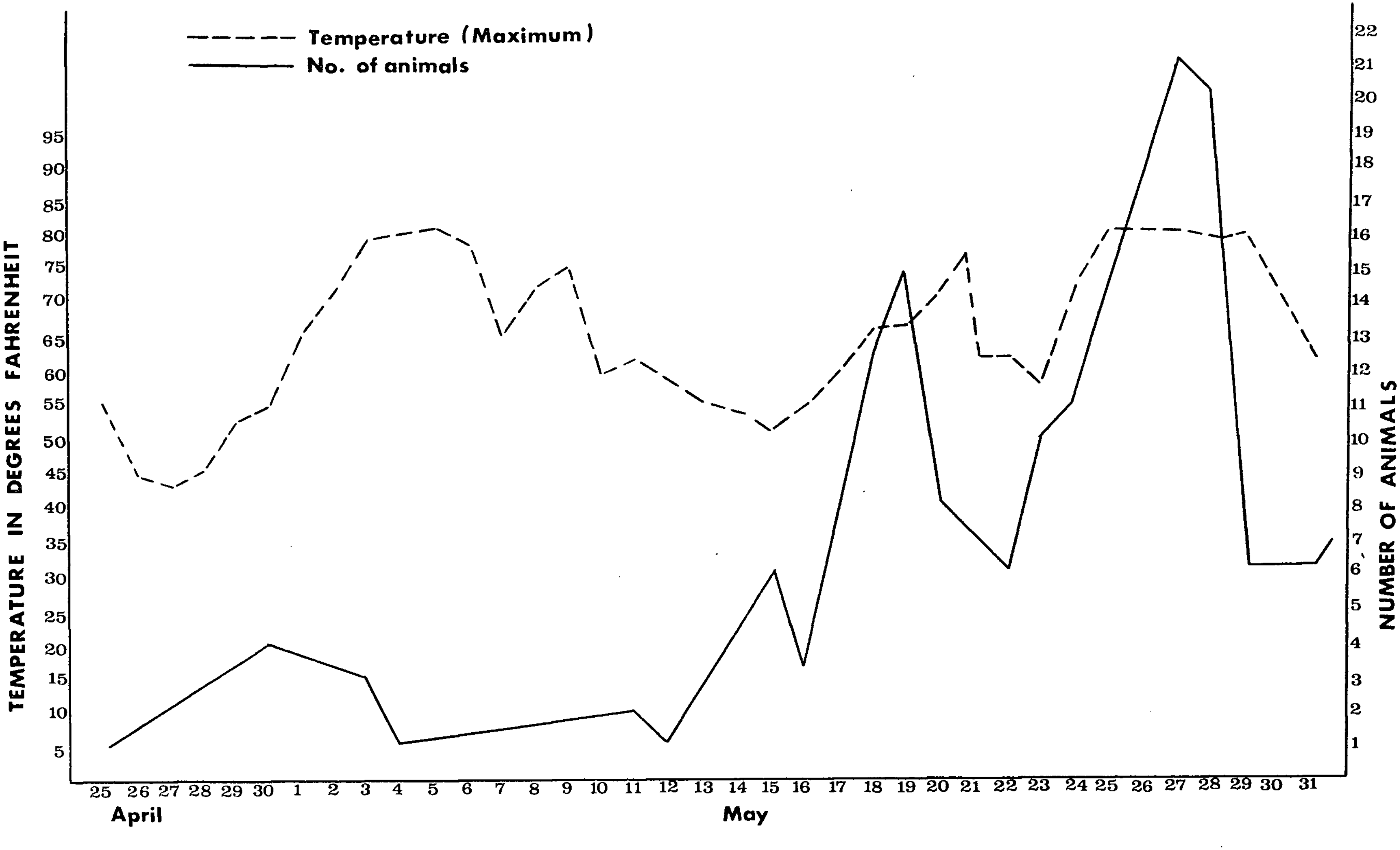

FIGURE 14. The relation between environmental factors and animal numbers in regions 2 and 3 during early spring in 1966.

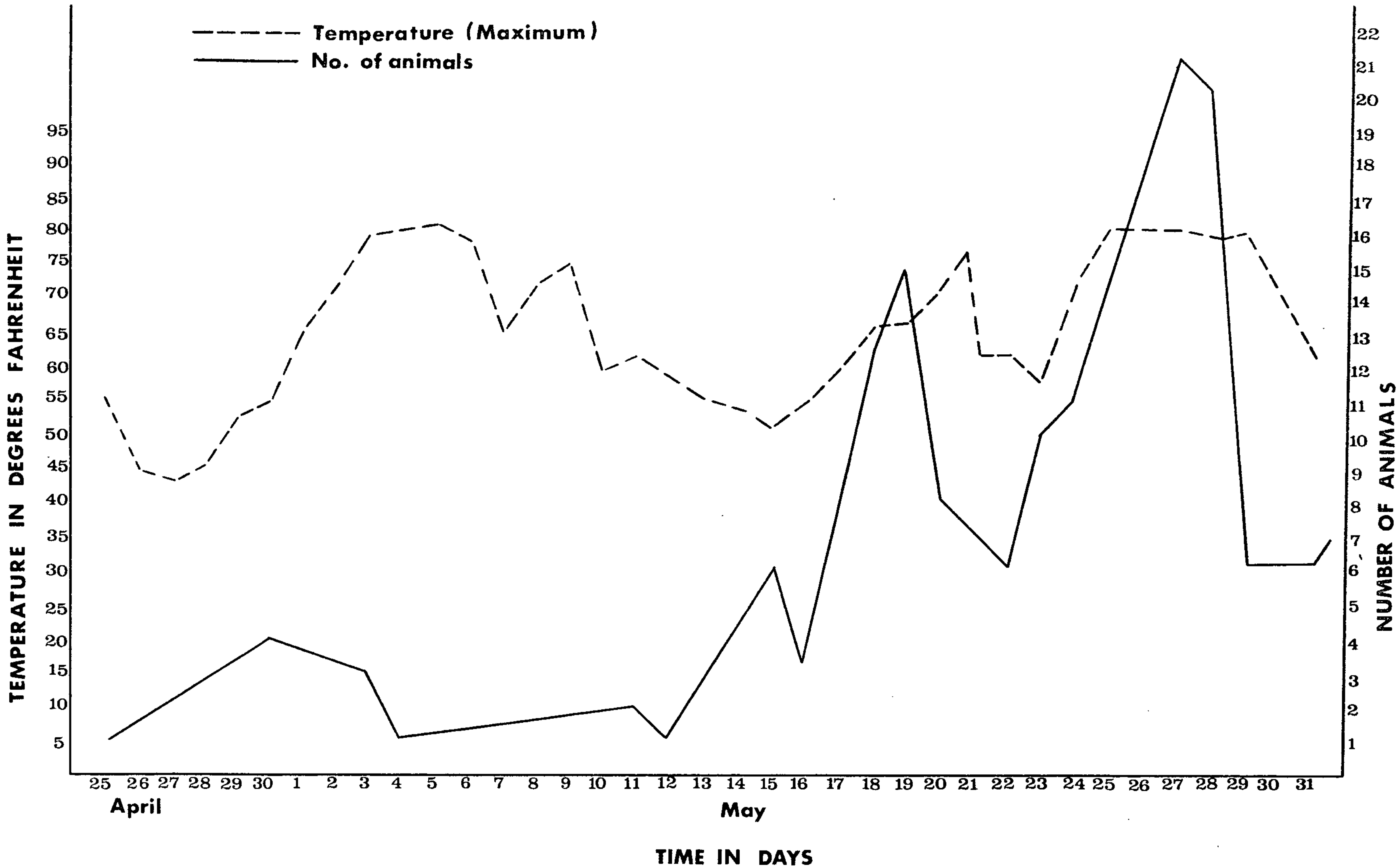

FIGURE 14. The relation between environmental factors and animal numbers in regions 2 and 3 during early spring in 1966.

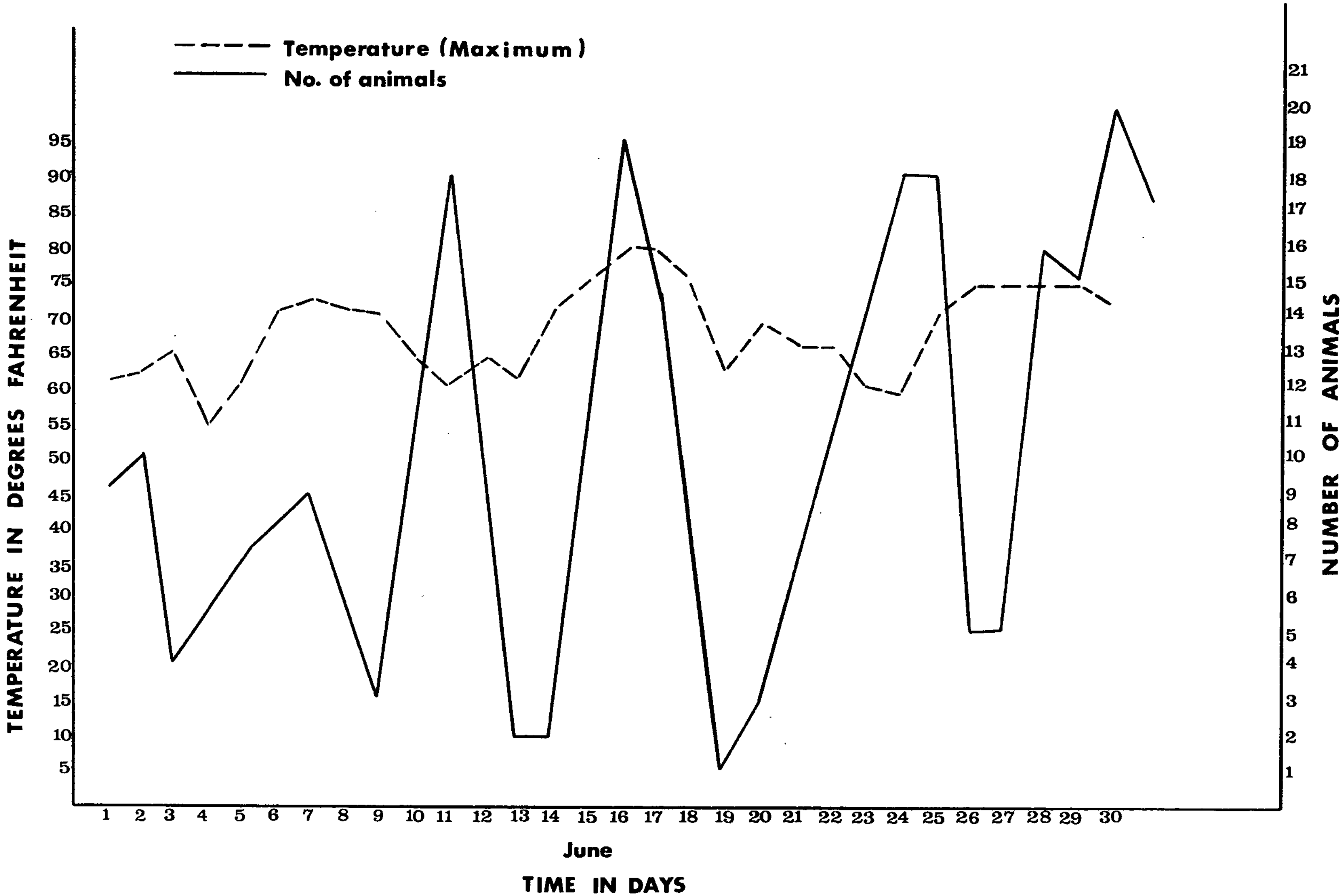

FIGURE 15. The relation between environmental factors and animal numbers in regions 2 and 3 during June of 1966.

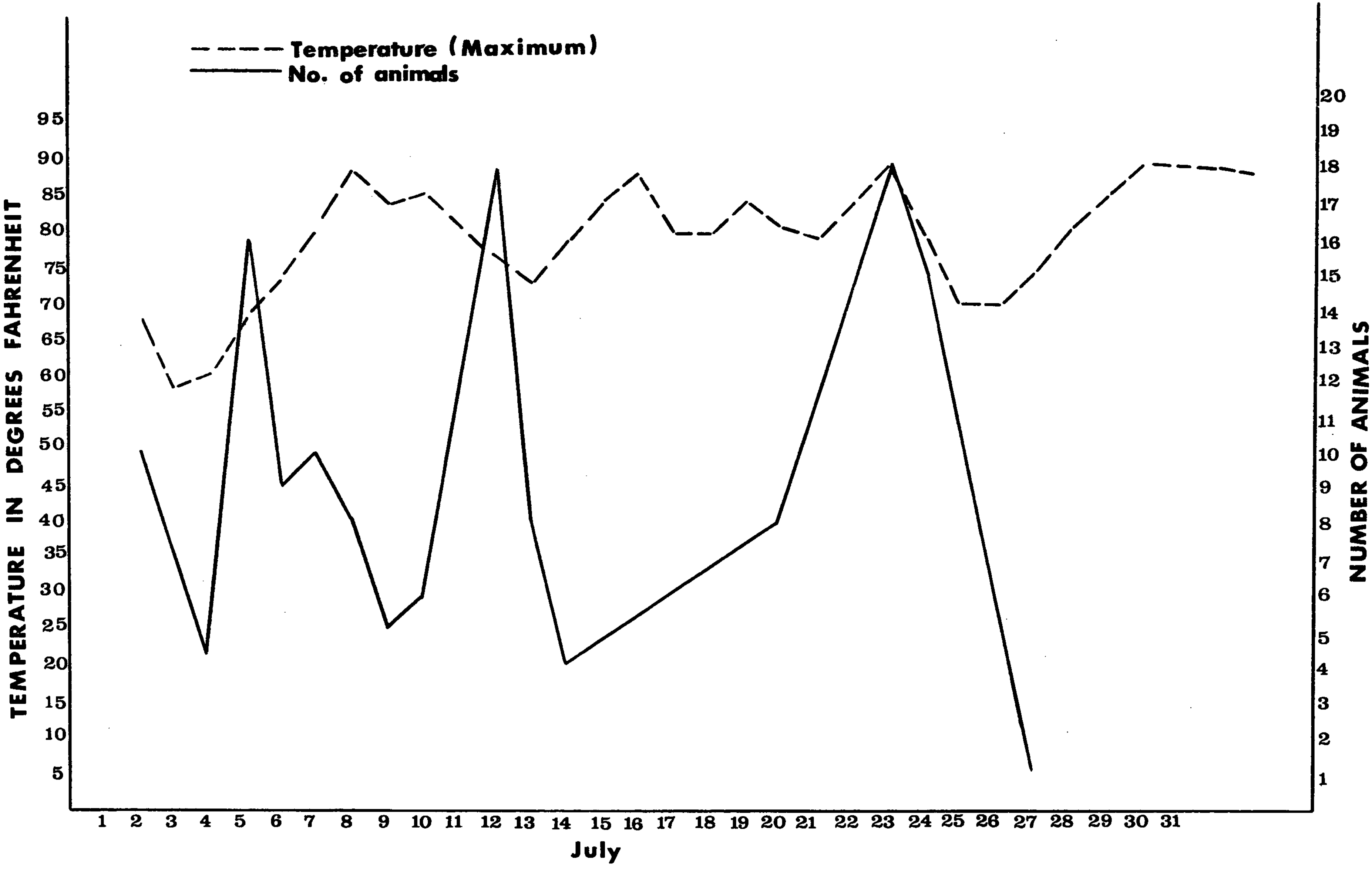

FIGURE 16. The relation between environmental factors and animal numbers in regions 2 and 3 during July of 1966.

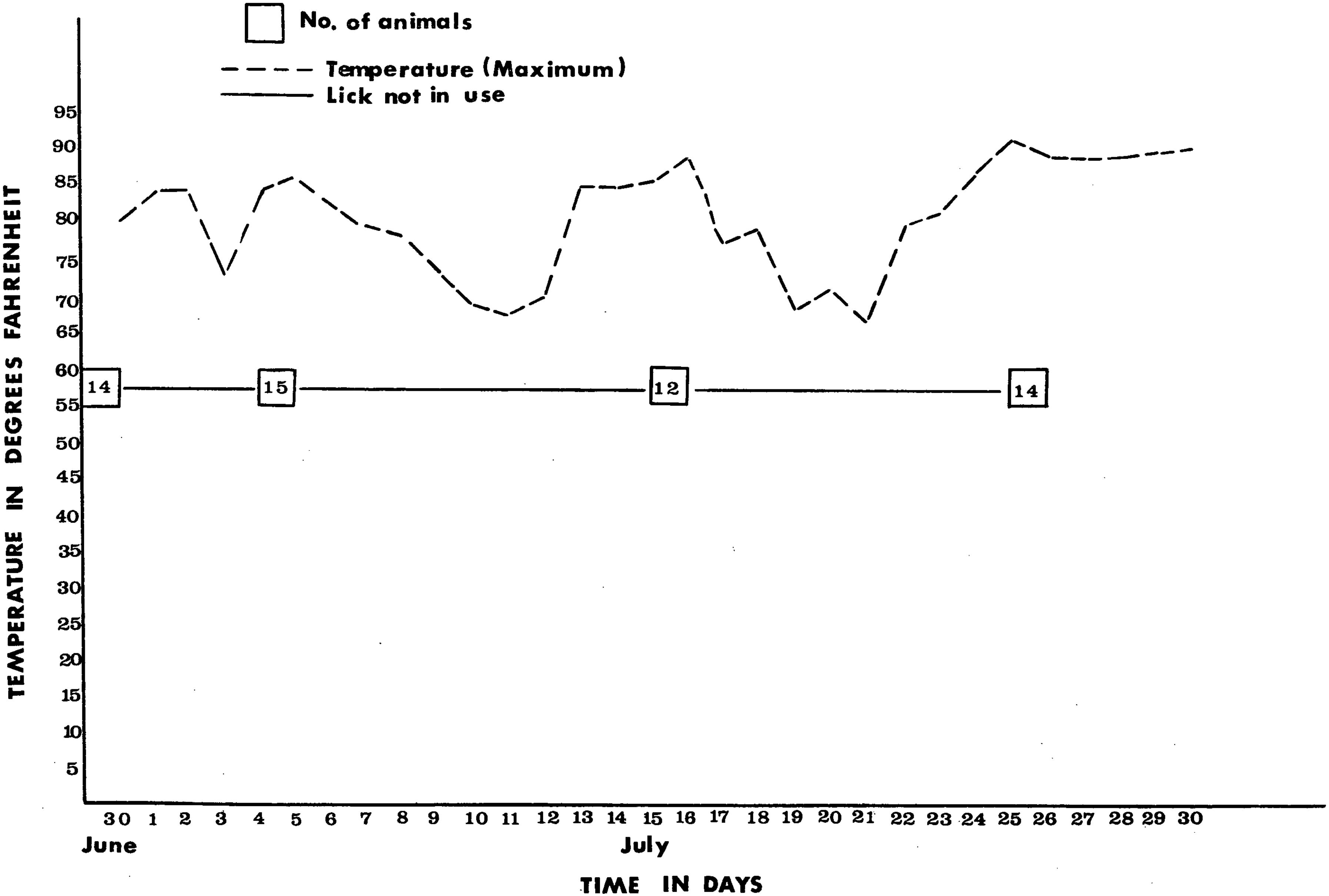

FIGURE 17. The relation between environmental factors and animal numbers in regions 2 and 3 at the Dutch Creek lick during July of 1965.

the two years.

In general, the summer of 1966 was warmer and sunnier, fluctuations in termperature were less pronounced, during the latter part at least and storms were less common than during the summer of 1965. In Figure 14 we see that use of the Toby Creek lick follows the fluctuations in temperature quite closely during the latter part of May. During the first part of May, intensive lick use had not yet begun. This is due largely to the lower average temperature, the greater flucuations of temperature and the frequent occurrence of storms which correspond to the drops in temperature. The correlation is thrown out of phase in June as average temperature rises and fluctuations are less evident. The changes in animal numbers follow more closely the pattern of storms, since temperature and storms can occur out of phase as well. This is shown in Table 6.

Table 6 The number of animals observed in region 2 and 3 during a period when a storm and temperature are out of phase.

		Prestorm			Storm		Post storm
		June			June		June
Region		5	7	8	9	10	11
2	No. of Animals	5	0	1	3	0	11
3		2	9	5	0	0	10

Very few animals were observed on June 9 or 10 during a storm, although temperature remained fairly high. On June 11 when the temperature dropped, animal numbers rose and though the weather was cool and cloudy, it was not stormy.

Although there were many peaks in temperature, during June and July, lick use was not solely restricted to these times and as stated, the degree of correlation became less pronounced as the summer progressed. The highest number and greatest activity was seen after storms and during periods of higher temperature. Prior to a storm, observations showed a decrease in numbers as shown in Table 7, for the latter half of May. After a storm, numbers usually increased for 2 to 3 days. The Dutch Creek and Toby Creek licks differ in the

Table 7 The movement of animals between regions 2 and 3 at the Toby Creek lick as a result of a severe storm.

		Prestorm			Storm		Post storm			
		May			May		May			
Region		18	19	20	21	22	23	24	25	27
2	No. of Animals	10	12	5	0	1	6	10	8	9
3		2	3	3	0	0	1	1	2	8

degree to which temperature and animal fluctuations coincide with storms. At Dutch Creek, animals returned to region 1 during a storm and in July no animals were observed in the lick under stormy conditions. As shown by Tables 6, 7 and 8, animals were not seen in the Toby Creek lick during a storm but were occasionally observed in region 2. Table 7 demonstrates the effects of a severe storm on animal numbers and

Table 8 The movement of animals between region 2 and 3 at the Toby Creek lick as a result of a moderate storm.

		Prestorm		Storm	Post storm		
		June		June	June		
Region		25	27	Morning of 28	Afternoon of 28	29	30
2	No. of Animals	18	5	0	6	9	10
3		0	0	0	10	6	10

movement. If storms occurred in quick succession, numbers would fluctuate rapidly as shown in Figure 15. Table 9 compares animal use days prior to a storm and during it. The difference is quite apparent and striking and shows the extent to which lick use is curtailed by storms. During a storm

Table 9 The effect of a storm on animal use days of region 2 and 3.

Period	Days of Observation	Numbers Observed In Lick Or Region 2	Animal Use Days
Prestorm	8	80	10
Storm	5	4	.8
Post storm	8	117	14.6

animal movement ceased almost completely but since animals were observed in region 2 before and after the storm, it was supposed that the majority were present there during the storm. The effects of a moderate storm as shown in Table 8 demonstrate this last statement. On this occasion, a storm occurred in the morning with a warm sunny period following in the afternoon. Animals observed in region 2 prior to the storm were observed there after it. The slow buildup of numbers following a severe storm is harder to explain. The possibility exists that some animals move to more protected areas, of which the location is not known. After the storm they supposedly return to region 2 or move to region 1.

The initiation of intensive lick use in May, at the Toby Creek lick was rapid and occurred immediately after a storm. As shown in Table 7 numbers were quite high from May 18 to May 20. Prior to this, from May 10 to 16, there was a period of cold stormy weather. Preceding this, goat numbers at this lick had been extremely low. May 17 was cloudy but warmer and the storm had evidently broken. As explained, there was a large buildup of animals from May 18 to 20. This was particularly impressive since 2 days previous there were very few goats in region 2.

As shown in Figure 16, animal numbers fluctuated although temperature remained fairly high, constant and storms were infrequent. Over this long period of constant weather, animals were free to move between the 3 regions and it does not seem unreasonable that these fluctuations should occur. The fluctuations indicate that changes in the number and composition of the population are occurring.

From these examples, it was thought that temperature and weather play an important role in regulating the movement of goats between regions 1, 2 and 3. It appears that inclement weather restricts goats from using the licks and region 2 serves as a place to wait out the storm.

Changeovers in the population and factors affecting it

Marking served as an excellent technique to note changes in the population, the time at which these changes took place and the possible factors regulating them. Animals were marked in early May, as shown in Table 5, and following this, in early June, unmarked animals were observed in regions 2 and 3. Males marked in May were not observed in June and it was supposed that some form of changeover had occurred. It is not known for sure whether the change was abrupt or whether new animals gradually replaced the earlier ones at the lick. The latter explanation seems more plausible at this time. As stated earlier, intensive use of the Toby Creek lick began after the storm of May 16. The storm of May 21 caused a certain amount of changeover since some animals marked prior to it were not observed after it. It was not until the stormy period at the end of the month that a complete changeover occurred. Since intensive lick use began just prior to the storm of May 21 and since animals were not in the lick during the storm, it appears that most had not spent a sufficient time in the lick and remained until the end of the month. It appears that the storm of May 31 affected the changeover at this time but more specifically, its relation to movements of animals between regions 1, 2 and 3 is not known. During early June, numbers were quite high but animals were unmarked.

Females began entering the lick in late June, causing the male - female changeover as explained in the section on differential use in time. This changeover was attributed to the lack of movement prior to kidding. During the latter part of June females were marked. In July, these animals were not observed in the lick, indicating another changeover had occurred. At this time, animals using the lick were all unmarked. Marking began again near the end of July, as use of this lick terminated for the summer but no results were obtained from this. The changeover of females can again be related to a severe storm at the beginning of July. It appeared that this storm moved one population of females out of the lick, while another entered after the storm. Observations showed that animals moved during good weather, between regions 1, 2 and 3 with storms between these periods curtailing activity in the lick.

Population estimate

Marking served as a crude method to estimate the population of animals using the Toby Creek lick. It has been suggested that approximately 3 to 4 changeovers of animals took place during the summer and this served as a basis to estimate the number of animals using the lick during the summer. Local reports had suggested that only 15 to 20 animals were using the Toby Creek lick each summer. If the highest daily total from each of the 4 changeovers is summed, it appears that approximately 70 animals were present at the lick during the summer of 1966. Using only one day's total should insure that these were 70 different animals. The winter and summer ranges from which these animals are travelling is not known but the distance varies from 5 to 25 miles. It is not known if the animals using the lick later in the summer are those travelling the longest distances. Marking and flying to determine ranges did not reveal to which ranges the animals had returned.

VEGETATIVE SOURCES OF MINERALS

Introduction

Animals and plants have certain mineral requirements, those of animals being supplied by the plants on which they feed. Thus, the plant removes elements from the soils and makes them available to animals. Plants can absorb large amounts of certain elements out of proportion to their abundance in the soil, and animals have a similar but less pronounced ability to select certain elements from the plants. Thus, animals require comparatively large amounts of sodium and traces of cobalt but it has not been found that these elements are necessary to the life of the plant. The macro-metabolic elements essential to plant life, include phosphorus, sulfur, calcium, magnesium, potassium and iron. The micro-metabolic elements include boron, manganese, copper, zinc, molybdenum and chlorine. The elements important to both animal and plant life and most often seen as deficiencies, are phosphorus, calcium, magnesium, potassium and chlorine with sodium and cobalt often appearing as deficiencies in animals (Gilbert, 1957).

Carnivorous animals, obtaining sufficient sodium from the flesh on which they feed, apparently do not crave this element. Herbivorous animals, lacking a sufficient amount in their food, may receive it as a supplement; in the wild state they may travel great distances to obtain it from a spring or lick (Gilbert, op. cit.).

Determination of the mineral element sought by goats from natural earth licks requires the elimination of most macro and micrometabolic elements. Seldom do the plants or animals offer any gross symptoms to assist in interpretation of a mineral deficiency. In general, where no obvious deficiencies are expressed as animal pathologies, search for the mineral in demand from lick soils has used two approaches: inference from soil analyses and from mineral "cafeterias" or selection trials. There have been no previous studies in which the use of licks by goats has been the main subject of inquiry. Few authors have attempted to relate chemical composition of the forage to chemical content of the lick, regardless of the species of animal involved. It is probable, however, that data from other wild species using the same vegetation will be illustrative in eliminating certain elements as attracting and serve as support for the attracting element.

Evidence established by mineral cafeterias (Stockstad, 1953) showed that all sodium compounds received a much greater degree of use by ungulates than did any other compound. It also seems significant that cobalt compounds were used to a degree second only to sodium. These two elements, as stated, have not been shown to be important in plant growth. Chloride compounds, other than sodium compounds, received a minor amount of use. The results of this study are shown in Tables 10 and 11. Similarly, preference tests carried out by Bissel (1953), showed sodium to be the important element. Of 8 stakes containing sodium compounds 6 were used excessively, giving a 75 percent index of usage. Stakes containing other compounds were not used at all.

Table 10 Comparative use by big game animals of mixtures offered in sixteen mineral cafeterias in western Montana, for a two year period (1951-52). From Stockstad (1953).

Compounds Used In The Cafeteria Mixtures	No. of Cafeterias In Which The Mixture Was Offered	No. of Cafeterias In Which Mixture Was Used	Frequency Of Use As Percentage	Total Amount of Mixture Offered In Pounds	Amount of Mixture Used In Pounds	Percentage Of Mixture Consumed	Relative Use Index
$NaHCO_3$	9	9	100.0	21	19.1	91.0	1.91
NaI	16	16	100.0	56	46.0	82.4	1.82
$NaCl$	16	16	100.0	56	40.0	71.5	1.72
NaH_2PO_4	16	16	100.0	56	41.1	62.3	1.62
$CoCl_2 \cdot 6H_2O$	16	5	31.2	56	2.8	5.0	.36
KCl	16	4	25.0	56	2.0	3.6	.29
$MgCl_2 \cdot 6H_2O$	16	3	18.7	56	1.7	3.0	.22
$(NH_4)_2HPO_4$	6	1	16.7	26	.7	3.0	.20
$CaCl_2 \cdot 6H_2O$	16	2	12.5	56	1.5	2.7	.15
H_3PO_4	5	0	0	8	0	0	0
KH_2PO_4	5	0	0	14	0	0	0
$Mg_3(PO_4)_2 \cdot 4H_2O$	1	0	0	2	0	0	0
NH_4Cl	16	0	0	12	0	0	0
HCl	4	0	0	9	0	0	0
$CuSO_4$	16	0	0	56	0	0	0
$FeSO_4 \cdot 7H_2O$	14	0	0	56	0	0	0
H_2SO_4	15	0	0	16	0	0	0
$(NH_4)_2SO_4$	8	0	0	28	0	0	0
CaI_2	5	0	0	11	0	0	0
MgI_2	4	0	0	6	0	0	0
NH_4I	5	0	0	11	0	0	0
$KHCO_3$	4	0	0	6	0	0	0
Control	16	0	0	56	0	0	0

Table 11 Comparative use by big game animals of five soil impregnation tests in western Montana, for a two year period (1951-52). From Stockstad (1953).

Compounds Used For Soil Impregnations	No. of Times Compound Was Offered	Number of Times Compound Was Used	Frequency Of Use as a Percentage	Total Pounds of Treated Soil Consumed (Approx.)	Percentage of Volume Used	Relative Use Index
$NaCl$	16	15	93.7	436	100.0	1.94
NaI	18	16	89.0	403	92.5	1.82
NaH_2PO_4	13	7	53.8	176	40.4	.94
KCl	18	10	55.5	50	11.5	.67
$MgCl_2 \cdot 6H_2O$	10	2	20.0	6	1.4	.21
$CoCl_2 \cdot 6H_2O$	18	1	5.6	3	.7	.06
$CaCl_2 \cdot 6H_2O$	18	0	0	0	0	0
$CuSO_4$	18	0	0	0	0	0
$FeSO_4 \cdot 7H_2O$	16	0	0	0	0	0
H_2SO_4	9	0	0	0	0	0
$(NH_4)_2HPO_4$	2	0	0	0	0	0
H_3PO_4	3	0	0	0	0	0
$Mg_3(PO_4)_2 \cdot 4H_2O$	1	0	0	0	0	0
$(NH_4)_2SO_4$	6	0	0	0	0	0

Packard (1946) studying bighorn sheep, put two types of salt blocks onto the range: one contained a combination of calcium, phosphorus, sodium chloride and iodine salts while the other was a block of sodium chloride. The sodium chloride block was consumed more rapidly.

Cowan and Brink (1949) conclude that magnesium and calcium are present in such abundance in the native rock of the region it is inconceivable that the vegetation is lacking in these elements. Similarly, iron is widespread in these soils. However, evidence suggests that boron is not essential in ungulate nutrition.

Work by Gordon <u>et</u>. <u>al</u>. (1954) has shown that phosphorus deficient cattle will select phosphorus when offered a choice of minerals. Since phosphorus was not selected in the preference tests described previously, it is not likely that phosphorus is attracting goats to the licks. Demarchi (1965) working in the Ashnola region of British Columbia gives the calcium-phosphorus ratio for 5 species of grass. Samples collected in March contained the lowest concentrations of both calcium and phosphorus while those collected in the fall contained the highest concentration and more nearly approximated the ratio of 2:1. Dietz <u>et</u>. <u>al</u>. (1962) working in Colorado, showed the phosphorus concentration to be highest in late spring with the calcium-phosphorus ratio closely approximating

2:1 at this time. In the fall the calcium concentration increased, varying the Ca:P ratio. McLean et. al. (1963) working in the interior of British Columbia showed that phosphorus was highest in the early spring and adequate for maintenance. The phosphorus level of feed, for the rapid growth of yearling cattle, is .2 percent as suggested by the National Research Council. Concentrations in the Ashnola bighorn range in March are much below this; those in Colorado in the early spring are much higher and those collected by McLean et. al. (1963) in July are slightly lower. McLean and Tisdale (1960) showed that phosphorus was much above the rapid growth requirements for yearling cattle, if concentrations were determined in May and June. This evidence would suggest that phosphorus is extremely low at the end of winter but that the new growth in early spring (especially the leaves) is extremely high in phosphorus. It has been shown that goats usually feed on the spring vegetation at low elevations before using the licks. It does not seem likely that phosphorus is attracting them to the licks after they have fed on vegetation containing the highest yearly phosphorus concentrations.

According to Gilbert (1957) potassium is one of the plant macronutrients that is somewhat less valuable to animals. Since it forms a high proportion of the ash of plants as shown in Tables 15 and 16, it should not cause any deficiencies in the animal.

The California Fish and Game Department (Bissel, 1953), concluded in their preference tests that chlorine was not the preferred element since sodium compounds with chloride and bicarbonate were selected with equal frequency. Cowan and Brink (1949) found extremely low concentrations of chlorine in the lick and conclude that this small amount probably is not attracting the animals to the licks.

In the preference tests carried out by Stockstad (1953) copper and sulfate compounds received no use. It has not been shown that animals deficient in manganese, zinc, molybdenum or copper will select forages containing high percentages of these elements. Since the deficiencies in the animal do not appear to be extreme, (no gross symptoms) it is not likely that these elements, if slightly deficient, would induce a craving in the animal.

Through successive elimination, most elements, with the exception of sodium and cobalt have been shown to be unimportant in attracting animals to the licks. It has been shown by Wallace, Toth and Bear (1947) in their examination of some New Jersey plants that sodium can be deficient in the vegetation. With the exception of a few accumulator plants, most of the 300 plants they examined were extremely low in sodium. Most species of grass ranged from .00 to .09 percent for sodium.

Other authors, notably: Harmer and Benne (1945), Collander (1941) and Lehr (1941) have shown that sodium apparently has no special function in plants. Plants benefit from it only in a situation of potassium deficiency. Huffaker and Wallace (1959) state that differences in uptake capacity between plant species seemed more important than potassium levels in determining the amount of sodium found in the aerial parts of plants. Potassium level appeared more important than plant species differences in determining the amount of sodium in the roots. There are a few exceptions to the above statements, as shown by sugar beets and some plants from saline areas, which may accumulate sodium.

Determination of major forage species of the goat

During the summer goats may be found over a wide range of elevations which includes all major vegetation zones in this area. The major forage species consumed at this time were determined using rumen samples and two confirming studies in adjacent areas. The analysis of rumen samples, shown in Table 12, suggests that grasses and sedges form a major part of the goat's diet at this time. Other studies suggest that the goat is a snipfeeder and will consume a large variety of forage types. The study of Cowan (1944) working in Banff and Jasper National Parks north of my area, and that of Saunders

Table 12 Rumen analyses from five mountain goats, showing the percentage of forage types.

ALL SAMPLES SHOT IN THE FALL OF 1965

I. FEMALE - LAZY LAKE LICK - ADULT

1. Grass - 61.5%
2. Browse - 38.48%

Trace: Rock, Fir Needles

II. FEMALE - WILDHORSE CREEK - ADULT

1. Grass - 98%
2. Browse - 2%

III. MALE - ELK CREEK LICK - YEARLING

1. Grass - 53.3%
2. Browse - 46.6%

Trace: Fir Needles, and grouseberry

IV. BULL RIVER AREA - ADULT MALE

1. Grass - 69%
2. Shrubs - 25%
3. Forbs - 6%

V. FINDLAY CREEK AREA - ADULT FEMALE

1. Grass - 88%
2. Shrubs - 12%

No conifer needles

All animals shot in alpine or subalpine areas

(1955), working south of the study area in Montana, list the major or preferred forage species for different seasons of the year. Using these two studies, forage species were collected if listed as preferred by Cowan or Saunders and if present in the study area. Some species were present in regions 1, 2 and 3 while others were restricted to only one region. The species composition varied from one site to the next showing the effects of elevation. In essence, the forage species collected represent a composite picture of the major forage species present in the area. Since neither selectivity trials nor a complete food habits study could be carried out, it was hoped that analysis of the major forage species listed by other authors would be adequate and serve as an indication of the sodium content of the vegetation.

Mineral content of the forage

The forage species collected were analyzed for total ash, sodium and potassium. The results are shown in Tables 13, 14, 15 and 16. The majority of forage species had sodium concentrations in the range of .001 percent to .007 percent, while the majority of potassium concentrations were between .5 and 1.5 percent. This gives an average sodium-potassium ratio of 1:250. The sodium values were in general, extremely low; much lower than any reports found in the literature. The potassium values appeared adequate for normal health and growth of the plant since no gross symptoms of potassium deficiency in the plants were noted. Gilbert (1957) reports that approximately .2 to .6 percent potassium in the dry matter of feed is required for animals. The concentrations in the forage of the study area appeared to meet these requirements.

Four samples were found to have slightly higher sodium values and are as follows: alpine bluegrass collected in September from region 1, .045 percent; alpine strawberry collected in September from region 1, .013 percent; northwestern sedge collected in the spring from region 1, .014 percent; Saskatoon berry collected in September from region 3, .016 percent. Field sampling procedure could account for this variation since the same species collected at other elevations and times do not show these higher concentrations. Other species collected in the same local area as these do not have such high concentrations. This may suggest that these four species may accumulate sodium where it is available. In general, the potassium concentrations tended to be lower in proportion to the sodium concentration of these four species. The sodium-potassium ratio of the four species is 1:11. The average potassium concentration is .52 percent. This coincides with information obtained by Harmer and Benne (1945) who suggest that in plants, the absence of sodium apparently results in an increased absorption of potassium.

Table 13 Forage samples collected in September, 1966, in regions 1, 2 and 3 at the Toby Creek lick, showing the amount of ash as a percentage dry weight.

Region 1	Ash as a % Dry Weight	Region 2	Ash as a % Dry Weight	Region 3	Ash as a % Dry Weight
Strawberry	7.7			Strawberry	5.2
Alpine Fir	2.4	Douglas Fir	1.2	Douglas Fir	1.6
Grouse Berry	2.3			Grouse Berry	.4
Willow	4.5			Willow	5.1
Alpine Bluegrass	13.3				
Northwestern Sedge	5.5			Northwestern Sedge	6.4
Idaho Fescue	3.9			Idaho Fescue	11.3
Thickspike Wheatgrass	4.4	Bluebunch Wheatgrass	4.3	Bluebunch Wheatgrass	5.1
Pine Grass	9.1	Pine Grass	13.1	Pine Grass	14.9
Saskatoon Berry	5.2	Saskatoon Berry	5.8	Saskatoon Berry	13.3
Bear Berry	.7	Bear Berry	3.0	Bear Berry	2.1
Aspen	5.1	Aspen	4.4	Aspen	4.2
Buffalo Berry	3.6			Buffalo Berry	6.0
Spike Trisetum	4.4				
<u>Carex</u> <u>Spp</u>.	2.4				
		Subalpine Needlegrass	3.4	Richardson Needlegrass	5.7
		Rocky Mt. Juniper	5.2	Rocky Mt. Juniper	4.2
				Kentucky Bluegrass	7.1

Table 14 Forage samples collected in the spring, 1966, in regions 1, 2 and 3 at the Toby Creek lick, showing the amount of ash as a percentage dry weight.

Region 1	Ash as a % Dry Weight	Region 2	Ash as a % Dry Weight	Region 3	Ash as a % Dry Weight
Strawberry	5.2				
Alpine Fir	2.2	Douglas Fir	2.2	Douglas Fir	2.2
Grouse Berry	3.2			Grouse Berry	6.4
Willow	3.1				
Alpine Bluegrass	5.3				
Northwestern Sedge	8.0	Northwestern Sedge	6.2	Northwestern Sedge	6.8
Idaho Fescue	6.6			Idaho Fescue	11.1
				Bluebunch Wheatgrass	11.0
Pine Grass	9.9	Pine Grass	11.6	Pine Grass	10.3
Saskatoon Berry	4.4	Saskatoon Berry	6.2	Saskatoon Berry	4.6
Bear Berry	2.4	Bear Berry	2.6	Bear Berry	1.8
Aspen	4.4	Aspen	7.0	Aspen	7.5
Buffalo Berry	4.1			Buffalo Berry	4.6
				Richardson Needlegrass	9.9
				June Grass	8.9
Carex spp.	7.0				

Table 15 Forage samples collected in September, 1966 in regions 1, 2 and 3 at the Toby Creek lick, showing the sodium and potassium concentrations as a percentage dry weight.

Region 1	% Na	% K	Region 2	% Na	% K	Region 3	% Na	% K
Strawberry	.0129	.68				Strawberry	.0077	.81
Alpine Fir	.0026	.61	Douglas Fir	.0030	.57	Douglas Fir	.0017	.54
Grouse Berry	.0026	.42				Grouse Berry	.0014	.24
Willow	.0055	.75				Willow	.0036	.64
Alpine Bluegrass	.045	.67						
Northwestern Sedge	.0014	.38				Northwestern Sedge	.0017	.29
Idaho Fescue	.0023	.52				Idaho Fescue	.0014	.24
Thickspike Wheat-grass	.0036	.86	Bluebunch Wheat-grass	.0015	.36	Bluebunch Wheat-grass	.0012	.30
Pine Grass	.0013	.54	Pine Grass	.0026	.65	Pine Grass	.0021	.67
Saskatoon Berry	.0049	1.17	Saskatoon Berry	.0091	.86	Saskatoon Berry	.016	.46
Bear Berry	.0043	.53	Bear Berry	.0035	.43	Bear Berry	.0031	.45
Aspen	.0073	.67	Aspen	.0051	.90	Aspen	.0036	.65
Buffalo Berry	.0038	.70				Buffalo Berry	.0055	1.00
Spike Trisetum	.0021	.64						
Carex spp.	.0041	.90						
			Subalpine Needle-grass	.0056	.71	Richardson Needle-grass	.0030	.53
			Rocky Mt. Juniper	.0071	.48	Rocky Mt. Juniper	.0033	.63
						Kentucky Bluegrass	.0015	.36
						June Grass	.0038	.35

Table 16 Forage Samples collected in the spring, 1966, in regions 1, 2 and 3 at the Toby Creek lick, showing the sodium and potassium concentrations as a percentage dry weight.

Region 1	% Na	% K	Region 2	% Na	% K	Region 3	% Na	% K
Strawberry	.0071	1.07						
Alpine Fir	.0024	.44	Douglas Fir	.0027	.57	Douglas Fir	.0020	.55
Grouse Berry	.0028	.45				Grouse Berry	.0035	.16
Willow	.0035	.83						
Alpine Bluegrass	.0041	1.09						
Northwestern Sedge	.014	.29	Northwestern Sedge	.0053	.49	Northwester Sedge	.0018	.35
Idaho Fescue	.0015	.64				Idaho Fescue	.0028	.48
						Bluebunch Wheatgrass	.0060	.77
Pine Grass	.0032	1.00	Pine Grass	.0060	2.36	Pine Grass	.0032	1.14
Saskatoon Berry	.0066	.87	Saskatoon Berry	.0063	.91	Saskatoon Berry	.0039	.97
Bear Berry	.0043	.36	Bear Berry	.0085	.32	Bear Berry	.0023	.31
Aspen	.0045	1.09	Aspen	.0051	1.41	Aspen	.0050	1.36
Buffalo Berry	.0049	1.23				Buffalo Berry	.0041	1.18
Carex spp.	.0055	2.04						
						Richardson Needlegrass	.0040	.48
						June Grass	.0020	.60

In his food analysis study, Saunders (1955) gives alpine bluegrass the highest observed summer use frequency by the mountain goat. The high degree of use coincides with the high sodium concentration and selectivity trials may prove interesting.

Denton and Sabine (1961) have shown that an intake of 100 m. - equivalents of sodium daily, led to a sodium craving in sheep, while an intake of 500 m. - equivalents per day reduced the craving. If a goat were fed solely on alpine bluegrass with a concentration of .045 percent, it would require 51.1 grams of the grass to supply 100 m. - equivalents of sodium per day and 255.5 grams to supply 500 m. - equivalents per day. This represents an almost impossible intake of alpine bluegrass in one day. Neither the distribution of this grass, nor its abundance in the study area is known. Since all other species are at least 7 times lower in concentration, it is not likely that the sodium requirements of the goat are being supplied by the vegetation.

It has been shown that all plants collected in the spring and fall, from regions 1, 2 or 3, have extremely low sodium values. Since the lick has been described as a runoff or accumulation site, it was thought that plants growing at higher elevations would have a lower sodium and ash content. As shown in Figures 18 and 19 the sodium concentration does

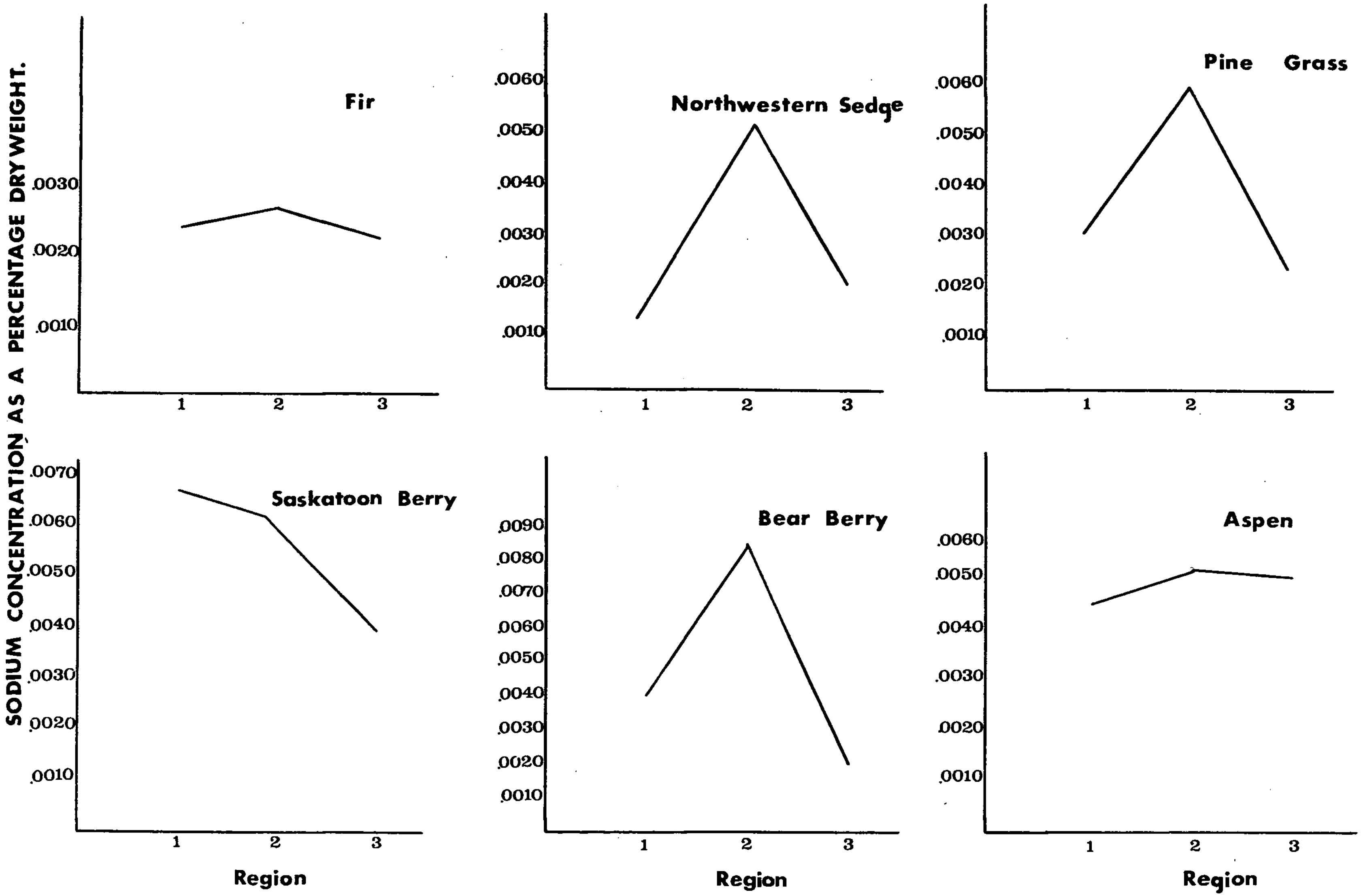

FIGURE 18. A comparison of forage samples collected in the spring showing sodium concentration plotted against elevational region.

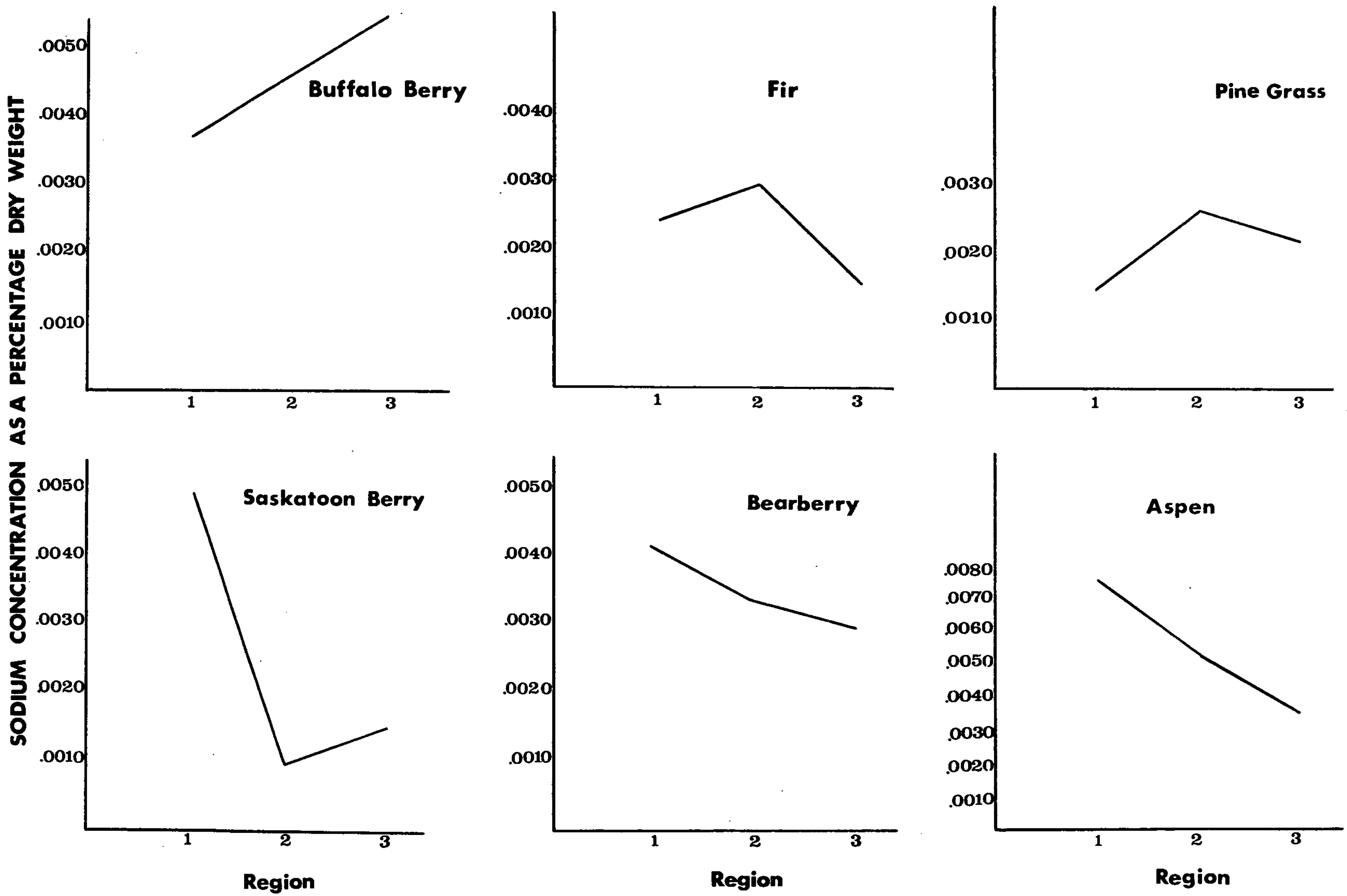

FIGURE 19. A comparison of forage samples collected in September showing sodium concentration plotted against elevational region.

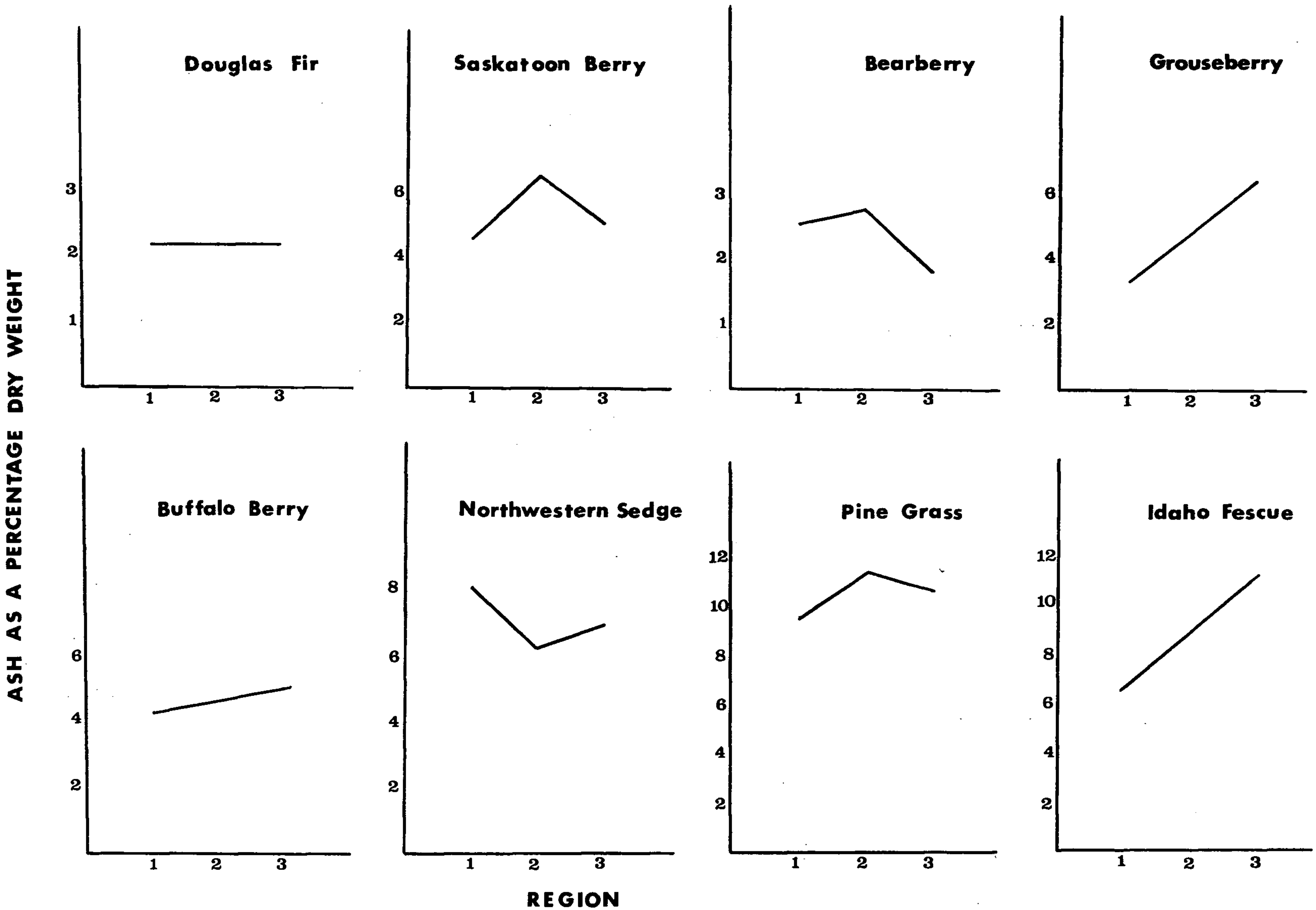

FIGURE 20. A comparison of forage samples collected in the spring showing ash as a percentage dry weight plotted against elevational region.

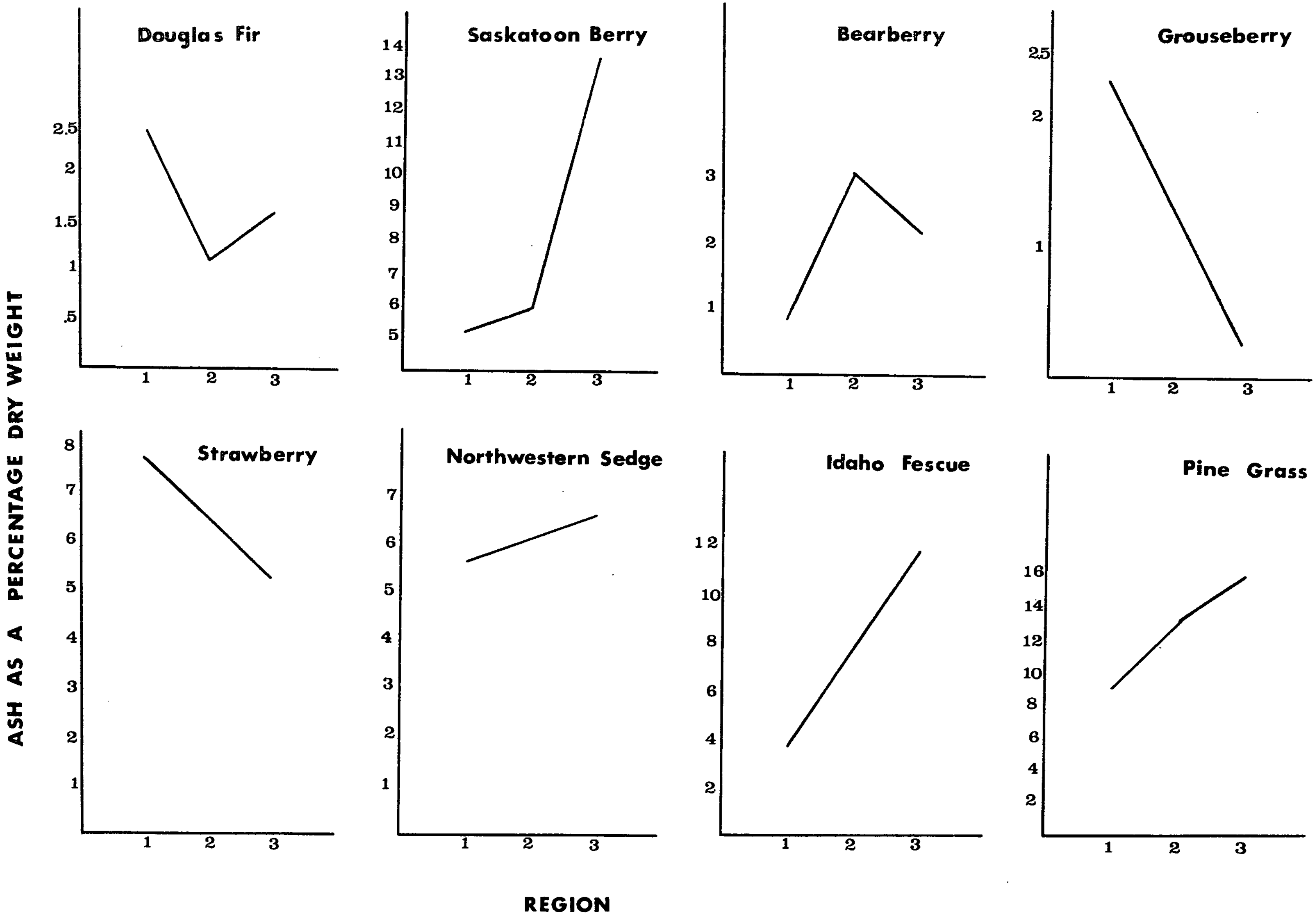

FIGURE 21. A comparison of forage samples collected in September showing ash as a percentage dry weight plotted against elevational region.

not appear to be consistently higher in region 3 in either spring or fall. In Figure 21, it can be seen that the ash content is not consistently higher in region 3, during the fall. In the spring, no consistent trend could be found as shown in Figure 20.

Plants collected in the spring and fall differed in the state of maturity. The spring sample consisted of plants in an early growth stage, containing a high proportion of water. Blair and Epps (1967), report that rusty blackhaw (Viburnum rufidulum) was highly succulent in the spring, with leaves averaging 79 percent moisture and twigs 76 percent. As shown in Figures 22 and 23, the shrubs and trees showed no consistent trend in sodium values from the spring to fall. The grasses and sedges collected in region 1, as shown in Figure 25 do not show any consistent trend from spring to fall. As shown in Figure 24, grasses and sedges collected at the lick are consistently higher in sodium in the spring than in the fall.

The great degree of variation evidenced here can well be attributed to soil, site factors, soil moisture and vegetation type. According to Cook and Harris (1950) the variation in chemical composition of plants is affected by the variability of botanical composition of the range, stage of growth, available soil moisture, temperature, soil types, site and

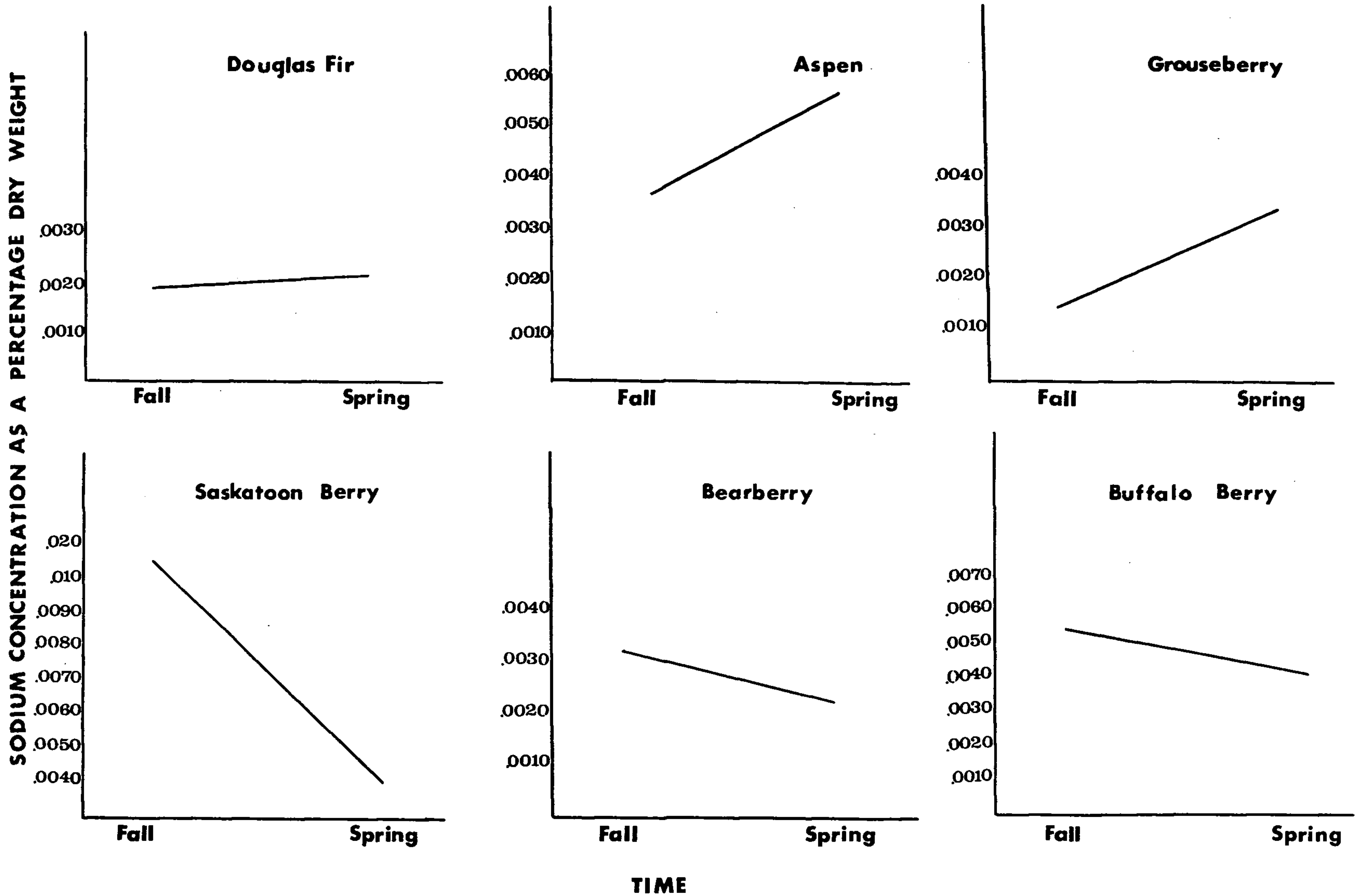

FIGURE 22. A comparison of spring and fall samples from region 3 using sodium concentration as a percentage dry weight.

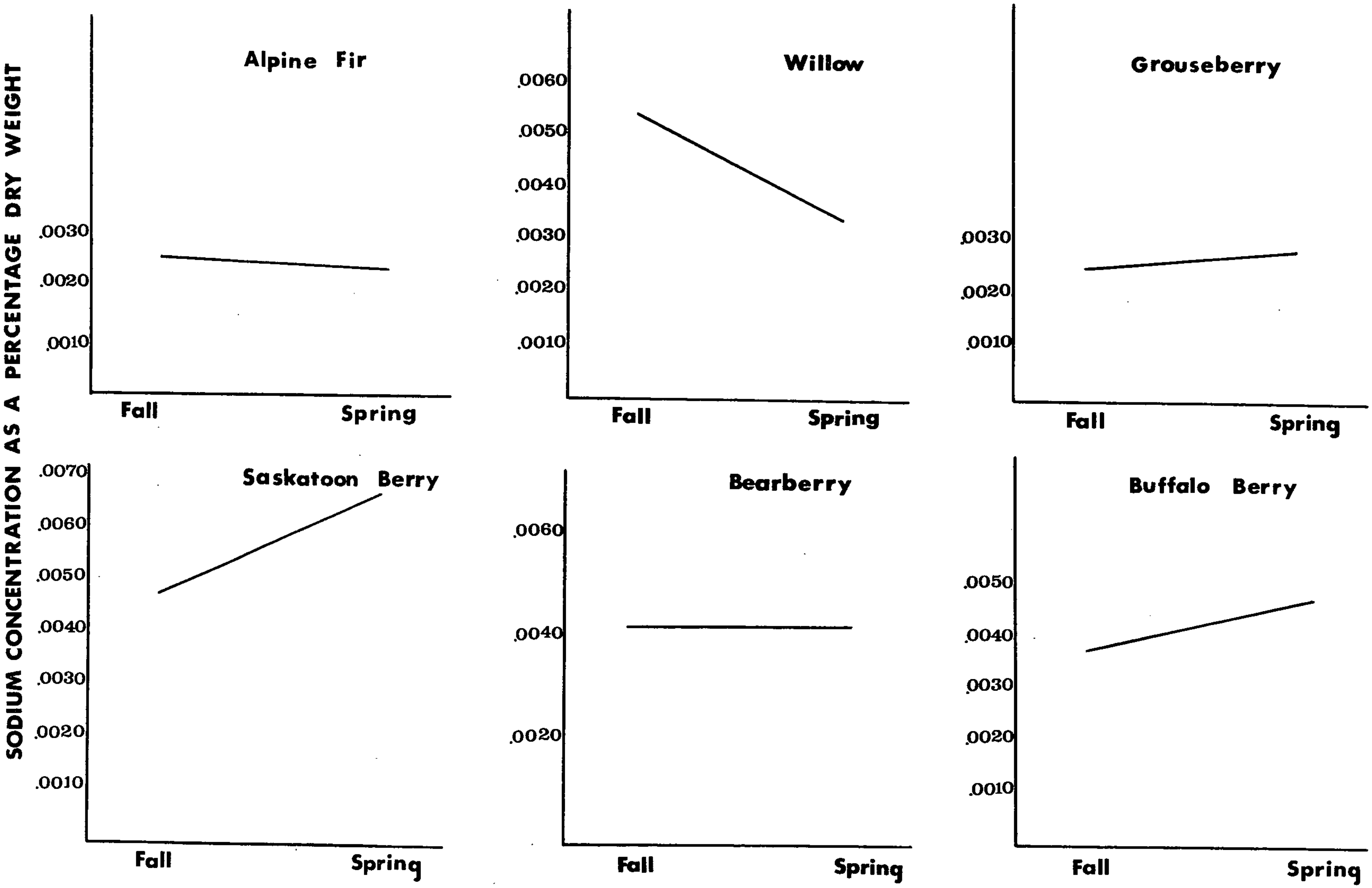

FIGURE 23. A comparison of spring and fall samples from region 1 using sodium concentration as a percentage dry weight.

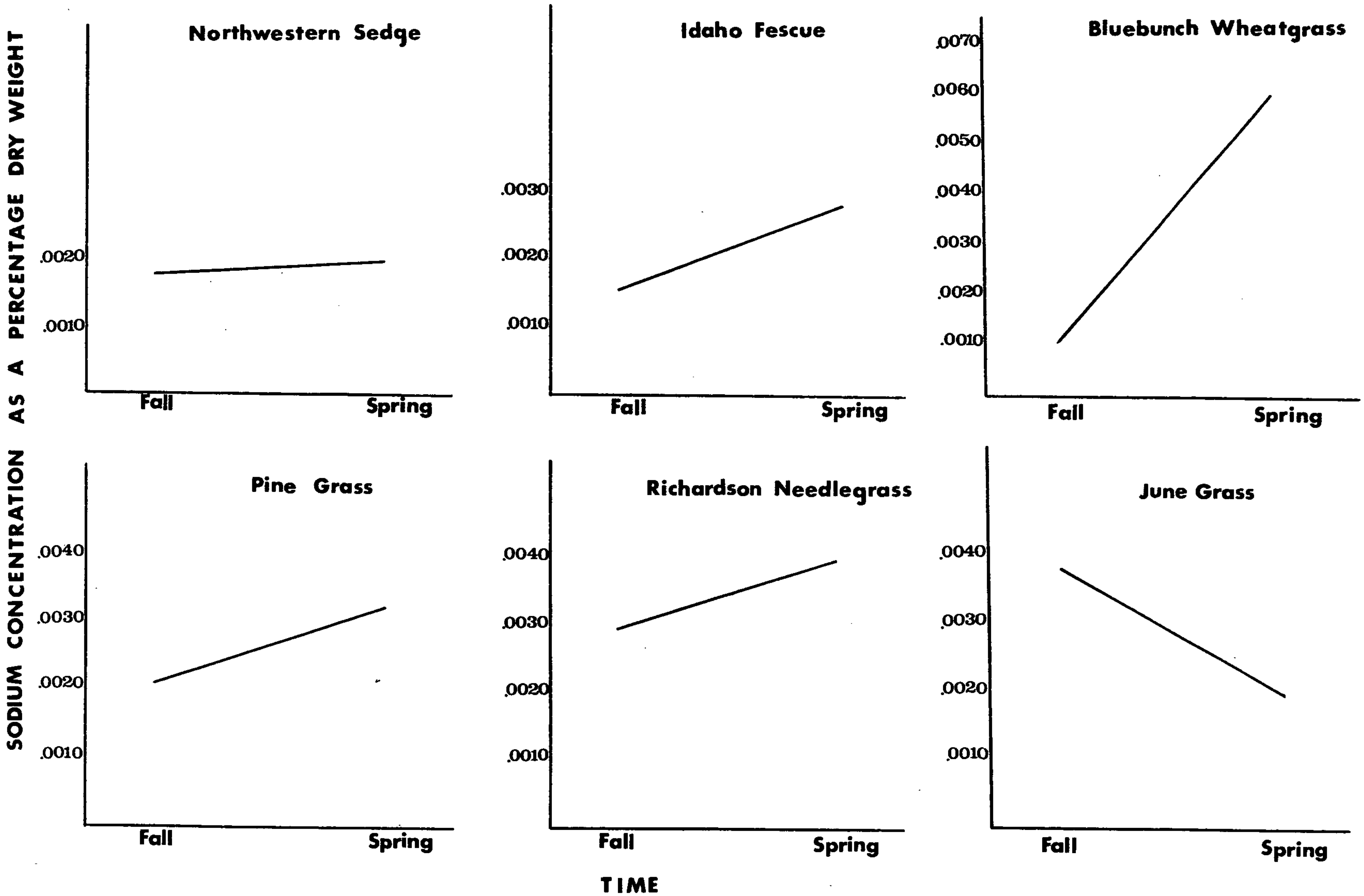

FIGURE 24. A comparison of spring and fall samples from region 3 using sodium concentration as a percentage dry weight.

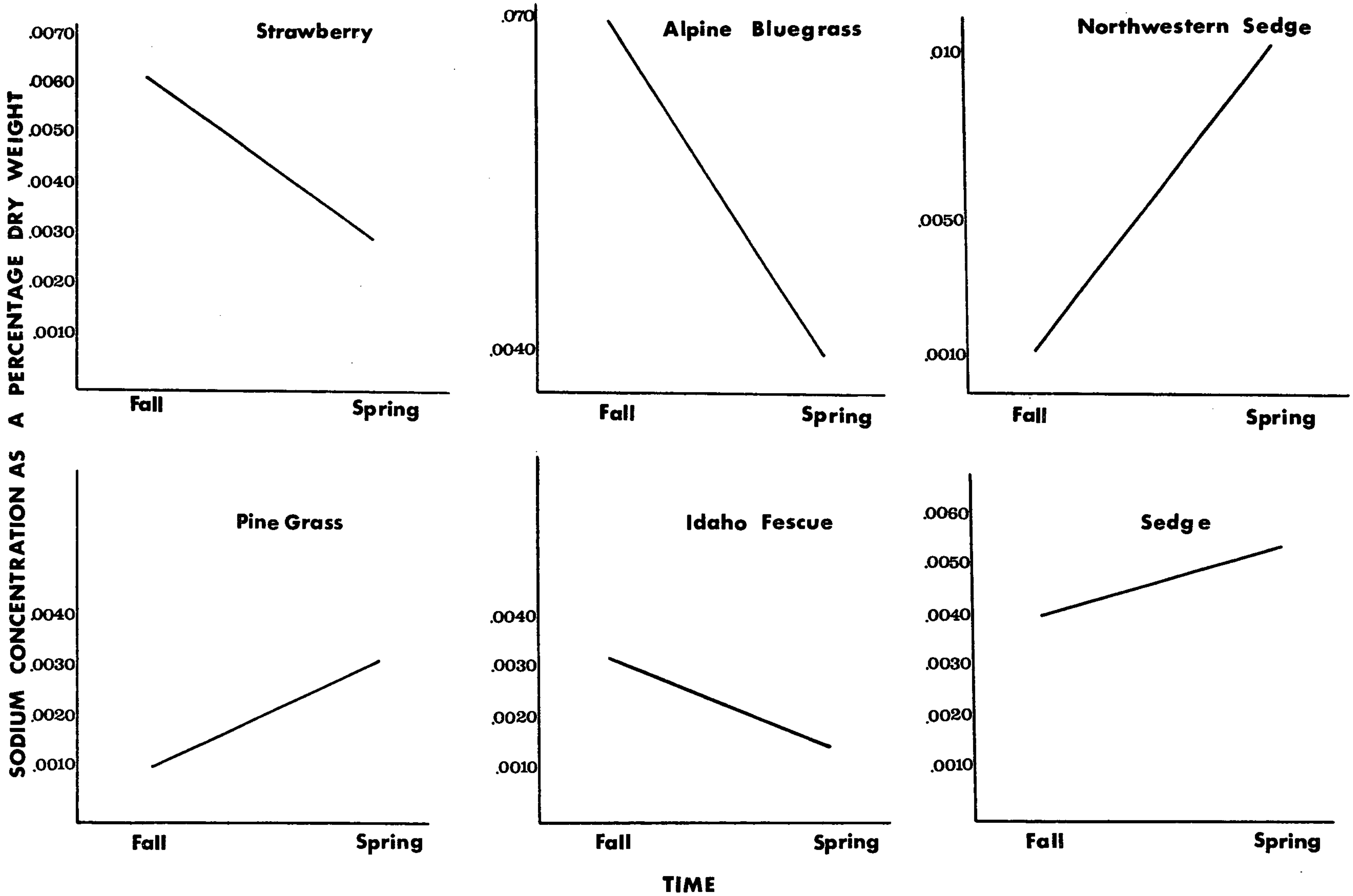

FIGURE 25. A comparison of spring and fall samples from region 1 using sodium concentration as a percentage dry weight.

general climatic conditions. It is not within the scope of this study to attribute the variation in ash and sodium content to specific environmental or biological factors but only to show where trends may or may not exist.

LICK SOILS

Introduction

In general, the use of natural earth licks by ungulates in the Rocky Mountain Trench of B.C. is confined to the summer months. At this time goats appear to prefer dry earth licks but on occasion visit mineral springs. Several other big game species utilize the licks in the study area during the early spring and summer but use by goats is predominant.

All licks are composed of a dry whitish clay but each contains a different amount of sand and gravel. It has been shown that if two licks are adjacent to one another in a certain area, goats usually prefer one over the other. In most cases, the preferred lick has less sand and gravel. Within an earth lick, sites are chosen by the goat to which it returns frequently to eat the soil. These high licking sites make up about 1 to 5 percent of the total surface area of the lick but approximately 90 to 95 percent of the actual licking occurs here. In most cases, these pockets of highly preferred soil occur among the roots of Douglas fir trees or in isolated spots in the lick. High licking sites at the Lazy Lake and Mary Creek licks are shown in Figures 26 and 27.

Where the high licking sites occurred on a bank, it was seen that they were in the "B" horizon or accumulation region of the soil profile. In some cases the licking sites

FIGURE 26. A high licking site at the Lazy Lake lick, among the roots of a Douglas Fir tree. A rattrap marker is shown in the foreground.

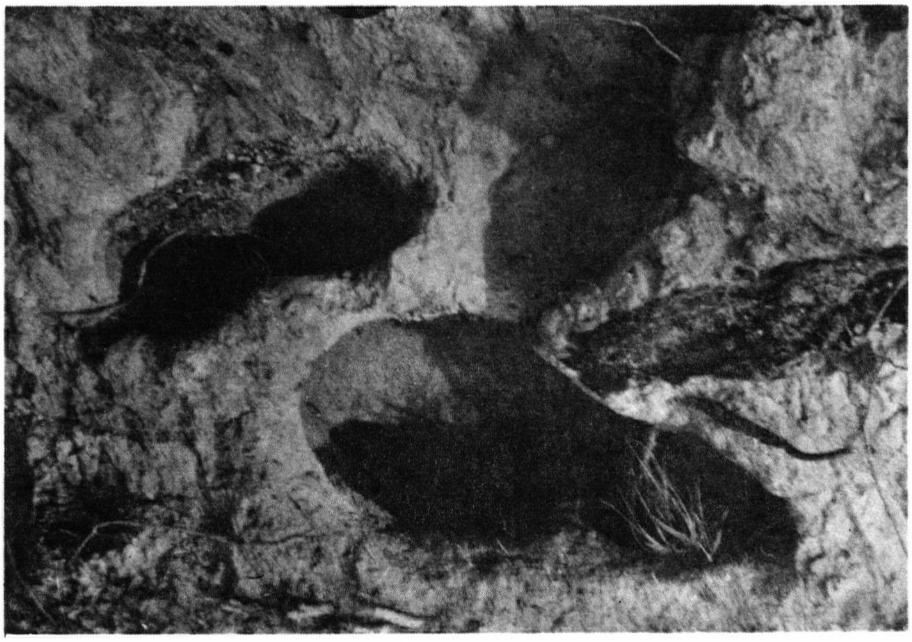

FIGURE 27. A high licking site at the Mary Creek lick.

extended into the lower region of the "A" layer. In these preferred sites the clay was usually dark brown and moist. Williams (1962) suggests that the character of the soil seemed to be a principal determinant of the quantity of soil consumed at a particular lick. He noticed that licks within the same salt ground would not always be used to the same degree. In the regions of heaviest elk use he states that a strong preference was shown for the more recently established salt licks. Consequently, cattle salt grounds that were constantly being replenished with salt were often used the heaviest.

Salt lick analyses carried out by the California Fish and Game Department (Bissel, 1953) showed that in every instance sodium was higher in the lick than in the control. Beeman (1957) found that the sodium concentration of the average lick was 16 times greater than the contents found in the water from 3 other licks, little used by animals.

High and low licking sites

As has been shown, certain sites in a lick receive more use than do others. Closer examination revealed the following physical differences: high licking sites contained a large proportion of moist brown clay and were usually among the roots of Douglas fir trees, the greatest amount of licking was usually in the "B" horizon of the soil profile; the low licking sites were composed of dry, grey clay, contained more

FIGURE 26. A high licking site at the Lazy Lake lick, among the roots of a Douglas Fir tree. A rattrap marker is shown in the foreground.

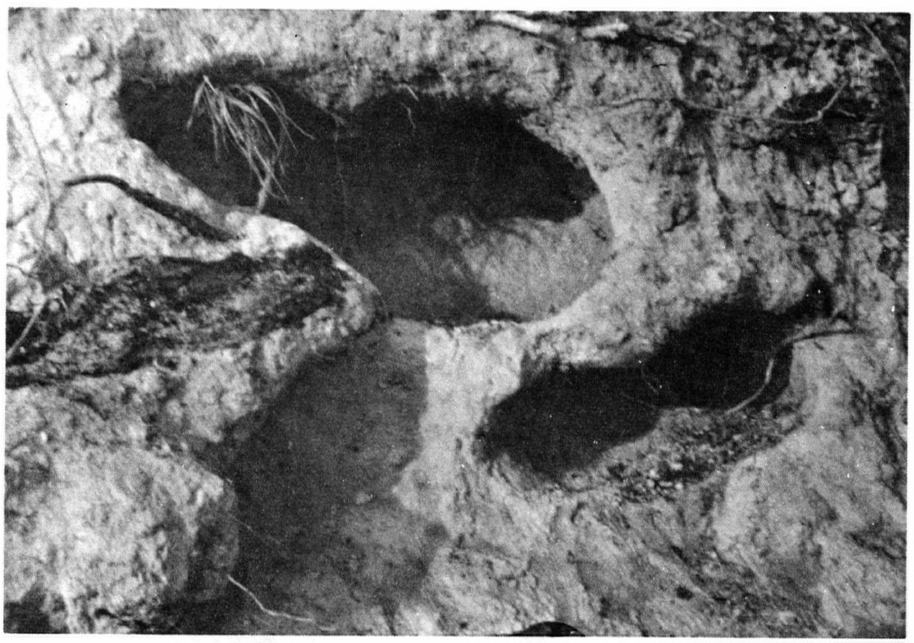

FIGURE 27. A high licking site at the Mary Creek lick.

sand and rocks and were not situated beneath fir trees.

At the Lazy Lake lick about 95 percent of the high and low licking sites are beneath Douglas fir trees. Those sites which are the deepest, contain more shale rock and appear the oldest, are the least preferred. The preferred sites contain less shale, more available soil and are not as deep. At the Dutch Creek lick observations showed that the animals moved in a pattern while using the lick. There are 3 groups of high licking sites which form a triangle. Each group is about 100 feet apart. On August 15, a group of 9 animals entered the lick. There were three females and three kids, a female without a kid and two yearlings. The animals moved from one high licking site to another, with occasional use of low licking sites when the preferred sites were being used by other animals or as they moved from one preferred site to another. The females with young dominated the high licking sites and could displace a female without young or a yearling from it by charging them. The yearlings occupied the high licking sites least often. It appeared that larger females could displace smaller ones from the high licking sites if both had young.

Mineral content

The mineral content of 3 licks was determined as shown in Table 17. At the Dutch Creek lick, samples from high and low licking sites were obtained from a primary and secondary lick. The sodium concentrations of two high licking sites from the primary lick (samples 5 and 7) are consistently higher than the sodium concentrations from the low licking sites in the same lick (sample 11). Samples from high licking sites in the secondary lick (samples 8 and 14) are again higher than those from low licking sites (sample 12) in the lick. Samples from high licking sites of the primary lick are higher than those from similar sites in the secondary lick. At Toby Creek, a similar trend is apparent, upon comparison of samples 10 and 15 to sample 9. Sample 10 was collected at the base of the "B" layer in the soil profile and sample 15 near the top of this layer. Sample 10 could almost be considered a low licking site due to its position in the profile. The sodium concentration closely approximates that of sample 9. At Lazy Lake a special sample was taken from a high licking site. This consisted of a white encrustation on the surface of the soil where goats spent much time licking. As shown in Table 17 the sodium concentration of this sample (number 16) was at least 10 times higher than that in other licks. The calcium and phosphorus content was also much higher. The cobalt was lower than the majority of samples from other licks.

On examining calcium and cobalt concentrations from high and low licking, it does not appear that a similar trend exists as that found for sodium. Phosphorus, as determined for that available to plants was not found in amounts sufficient to attract animals.

New licks

During the two summers of field work it became obvious that new lick sites were being created.

At Lazy Lake two new lick sites were found during the summer of 1966. It was known that one lick had not been there in the fall of 1964. Both sites were close to the main lick. One was approximately two feet square and one foot deep, the other slightly smaller. Since they were both in the vicinity of the main lick it seemed probable that new licks should be started because old licks become clogged with shale rock and roots of Douglas fir. Since deer, sheep and goats were all present in this vicinity it is not possible to distinguish the role each species played in their formation.

At Dutch Creek a unique situation occurred. During the summer of 1965 a logging operation was undertaken about two miles below the lick on the guide trail which ran from this site past the lick. This operation was discontinued at the end of the summer in 1965, after the goats had ceased using the main lick. Many skid trails had been extended to within one mile of the lick. Around the end of June during the summer of 1966, goat hair was found on the guide trail below the main

Table 17 Chemical analyses of 3 licks, comparing high and low licking sites.

	Sample No.	Description	NH_4Ac, pH = 7.0 (p.p.m.) Na	Ca	Co	NH_4Ac, pH = 4.0 (p.p.m.) Na	Ca	Co	Available P (p.p.m.)	
D	5	Good site (1)	185	10,000	2.0	207	21,400	3.0	0	Primary
D	6	Skid trail	438	10,400	N.D.	440	85,000	5.0	0	
D	7	Good site (1)	207	11,000	2.0	185	24,000	4.0	0	Primary
D	8	Good site (2)	169	1,050	N.D.	148	1,050	2	0	Secondary
T	9	Poor site	160	8,400	2.0	160	29,400	4.0	0	Primary
T	10	Good site	160	8,000	2.0	160	29,200	4.0	0	Primary
D	11	Poor site (1)	138	11,000	N.D.	115	21,400	4.0	0	Primary
D	12	Poor site (2)	115	10,400	2.0	115	18,600	2.0	0	Secondary
D	14	Good site (2)	160	12,000	N.D.	160	25,000	4.0	0	Secondary
T	15	Good site	345	7,200	N.D.	345	22,600	3.0	0	Primary
L	16	Good site	5,500	47,000	N.D.	4,950	62,000	2.0	25	Primary

N.D. - Not Determinable

D = Dutch Creek lick
T - Toby Creek lick
L - Lazy Lake lick

(1) - Main lick
(2) - Secondary lick

lick and on the skid trails. Many fresh tracks and much fecal material was also present. It appeared that some goats, upon reaching the main lick continued down the guide trail to the skid trails where licking was done. Evidence of licking was present on the three to four foot banks of the skid trails. Since goats were not believed to have ever moved down this low before it led to many speculations. Mineral content of the main lick was compared to mineral content of the earth from the skid trails as shown in Table 17. Goats are very specific in the trails they use and deviation from them is limited. It is concluded that goats wander through the timber very little. It is not thought that they began using the skid trails by accident but by using a definite trail came to acquire a new lick site. The comparison of analyses shows that the sodium concentration of the skid trails is much higher than the high licking sites in the primary lick. This is in agreement with the statement of Beeman (1957) made earlier in this section. At this time, goats have had access to this new lick for only one summer. During the summer of 1967 it will be interesting to see if more goats use this lick. At Dutch Creek, the secondary lick is more accessible to goats entering from region 1, the primary lick is less accessible and the skid trails are in timber, little travelled by goats. The sodium concentration and degree of use by goats is highest in these latter two licks.

The selectiveness shown by goats for sites high in sodium leads to the conclusion that sodium is the attracting element.

SODIUM IN THE ANIMAL

Introduction

The efficiency of the various homeostatic mechanisms in the animal body is very high. The regulatory functions of the renal mechanisms, the role of the adrenal hormone; aldosterone, in minute quantities, is a most important regulator of sodium balance, the transfer of water between cells and extracellular fluid, the role of bone in mobilizing sodium in response to acute acidosis and salt depletion and the role of the central nervous system and its influence on sodium metabolism all contribute to this efficiency (Forbes, 1962). He feels that serum sodium remains constant under conditions of a sodium load which is excreted promptly or in the case of a sodium deficiency, sodium excretion drops to a very low level within two to four days after removal of sodium from the diet.

Certain conditions are associated with a disordered sodium metabolism. When homeostatic mechanisms fail because of disease, or when their regulatory limits are exceeded by the magnitude of the stress put upon them, sodium metabolism is upset. Some conditions which may lead to disordered sodium metabolism are: extreme gastrointestinal losses, urinary losses associated with renal insufficiency, adrenocortical failure, a central nervous system disease and extreme sweating. These conditions leading to sodium depletion usually result in clinical symptoms such as: a decrease in serum sodium, a decrease in plasma volume, an increase in the hematocrit value. Shock and eventual death may result (Forbes, 1962).

It has not been shown that any of the above disorders, usually associated with the individual, are common to populations of ungulates using natural earth licks. Since gross clinical symptoms have not been reported for animals using licks, it is likely that the homeostatic mechanisms are functioning normally in preventing a severe salt depletion. Marriott (1950) says that if only intake of food ceases and water continues to be taken, it is a considerable time, in the absence of abnormal salt losses such as those previously described, before serious salt depletion occurs.

During the summer of 1966, goats entering the Toby Creek lick were observed to have diarrhoea. The material they were passing was entirely organic and no clay was found in the droppings. This would indicate that diarrhoea occurred before they entered the lick, probably caused by the shift from mature winter forage to succulent spring forage. Since diarrhoea is a gastrointestinal disorder, abnormal sodium loss to some degree could occur. According to both Marriott (1950) and Weisberg (1953), urinary loss of sodium occurs for the first two to four days on a diet high in water and extremely low in sodium. It has been found by Sellers and Roepke (1951) that extreme diuresis increased several fold, the excretion of calcium, sodium, chloride, and phosphate. During diuresis, the urine contained more of these electrolytes as they were "washed out by the water," than urine collected before diuresis.

It would appear, that to a limited extent, abnormal salt losses can occur; that excessive water intake can remove sodium during the first two to four days and diuresis can "wash" sodium out of the body. The goat, as described, is affected by these three factors prior to entering the lick.

Serum sodium values obtained under these conditions, for the goat, ranged from 141 to 153 m. - equivalents per litre as shown in Table 18. The stressful conditions of trapping and handling were not expected to alter the normal sodium range as the literature does not suggest these factors as affecting serum sodium values. The serum sodium values obtained were comparable to those found in domestic sheep (146 - 161) and cattle (122 - 166) (Dukes, 1955). It was thought that the serum sodium values are probably within a normal range for the mountain goat. The value for the kid is higher as is the case for most young animals. According to Vrzgula (1965) the highest sodium, potassium and calcium values were found in the serum of calves immediately after birth. Mean values declined during growth and in cows continued to decline slowly but significantly throughout life.

Table 18 Some serum sodium values and the packed-cell volume obtained for the mountain goat.

Class		Serum Sodium In m.eq/L.	Packed Cell Volume in %	Age in Years	Date	Movement
1. Yearling male		153		1.5	May 26	To lick
2. Adult male		142	38	10.	June 1	To lick
3. Adult male		151	41	5.5	June 12	To lick
4. Adult female (no young)		153		4.5	June 19	To lick
5. Adult female (with young)		141		3.5	July 1	Out of lick
6. Adult female (no young)	A.	151	46	3.5	July 12	Out of lick
	B.	152	50		July 15	Holding pen
	C.	152	42		July 28	Holding pen
7. Adult male		153		6.5	July 19	To lick
8. Female kid		160		3 months	August	Out of lick

Comparison of sodium values of animals moving into and out of the lick.

Examination of a small sample of goats of both sexes (Table 18) revealed that there were no significant differences in serum sodium values between goats coming to the lick for the first time and those that had been using it. Serum sodium values lay between 141 and 153 m. eq./litre and are thus within a normal range for healthy ungulates (Dukes, 1955).

It is known that serum sodium levels are maintained by some species even after they have developed a craving for the mineral as a consequence of dietary deficiency. For example, Smith and Aines (1959), working with dairy cattle, found that unsupplemented cows developed salt hunger in about two weeks even though serum sodium values remained normal. There was no difference in serum sodium between supplemented and unsupplemented groups after 13 months, or between the first collection period at one month and the last collection period at 13 months. Beilharz (1963) working with sheep states that the appetite for sodium and plasma concentration can vary almost independently.

A single attempt to alter serum sodium values by feeding vegetation known to be sodium deficient, failed (Table 18).

The hematocrit values, as shown in Table 18, range from 38 percent to 50 percent. Rosen and Bischoff (1952) report a packed-cell volume of 44.8 ± 0.5 percent for several subspecies of Odocoileus. Browman and Sears (1955) give the packed-cell volume of Rocky Mountain mule deer in Montana as 39.6 percent. Kitts et. al. (1956) suggest that such factors as high altitude, muscular exercise, heightened environmental temperatures and certain pathological conditions are known to cause an increase in the packed-cell volume. They state that the certainty with which such field data may be interpreted must rest largely upon the availability of normal values obtained from animals reared under known environmental conditions. He also suggests that the packed-cell volume increases with increasing age. Deer (Odocoileus) on a high plane of nutrition had a packed-cell volume of 40 percent in the 20 - 100 day age group and one of 58% in the 395 - 465 day age group. Data collected on the mountain goat would suggest that its packed-cell volume is within a normal range.

Blood serum studies conducted on other animals show trends of certain minerals in the serum over one year periods. Stufflebeam (1964) states that Hereford cows which always got sufficient mineral and protein supplement showed no seasonal trend in serum calcium and showed a sharp decline during winter of serum phosphorus. According to Payne (1964) inorganic phosphorous was lower during lactation than in the dry period and fell with advancing age; calcium was not affected by lactation but fell slightly with age. Results were obtained from plasma studies on the cow. Vrzgula (1962) studying Pinzgou cattle found that the lowest values for sodium, potassium and calcium were in April. The highest values were in the summer and late fall. He attributes this to the greater amounts of minerals and vitamins in the feed. Denton (1961) found that when Merino sheep were offered water and solutions of NaCl, $NaHCO_3$, or KCl, they showed a preference for $NaHCO_3$. Although their diet supplied about 100 m. - equivalents of sodium daily, most sheep drank the solutions and increased their intake to 500 m. - equivalents daily. A study conducted by Devlin and Roberts (1963) on wether lambs for a period of 30 days showed that the concentrations of sodium, potassium and chloride in serum was the same on all diets. The daily intake of three diets consisted of 4, 44, and 129 m. - equivalents of sodium.

It has been shown that serum sodium is regulated to a high degree in the absence of abnormal conditions. It does not appear that sodium levels in the blood change over short periods due to the control of homeostatic mechanisms and it is likely that the serum sodium values obtained for the goat are normal. No difference could be found between animals entering and leaving the lick or among animals using the lick over the summer.

From the preceeding section on vegetation it is known that phosphorus in plants is highest in early spring and calcium gradually increases over the summer to reach a maximum in late fall. The blood phosphorus declined during the winter and was lowest during lactation. Sodium appears to follow this pattern. Calcium does not appear to change as markedly. This suggests that while the three elements may be reduced in the animal during the spring, sodium is the only one not readily available from the vegetation.

SUSPECTED SELENIUM DEFICIENCY

During the summer of 1966, trapping operations brought many animals under stresses to which they were not accustomed. Animals were restrained with ropes, causing them to struggle vigorously for varying lengths of time. The resulting gross symptoms closely approximate those described by Muth (1963), for a selenium deficient myopathy termed white muscle disease. Trapped animals, upon release, were hesitant or unable to rise to their feet so that many had to be lifted into a standing position. When in this position, all animals lacked control of their hind limbs and pelvic region and showed reduced maneuverability. Recovery occurred for most in about 5 minutes as they moved out of the trap. These symptoms were at first attributed to partial loss of circulation.

Three animals, two females and a kid, which did not recover, were kept in a holding pen after trapping. All died following symptoms of loss of muscle control. Muscle paralysis began in the hind legs and pelvic region, moved to the front limbs and eventually enveloped the entire body. During the period before death, the goats ate, drank and defecated normally. One female had extreme difficulty breathing just prior to death, probably due to loss of control over the thoracic muscles. One female showed edema in the hind legs. According to Rosenfeld and Beath (1964) edema is common in animals with white muscle disease. They state that spontaneous recovery is also common and this may explain the short period of paralysis exhibited by trapped animals. The kid died three weeks after trapping, one female after two weeks and the other in two days. Autopsies did not reveal abnormalities in the animals.

As a result of these observations, 12 plant samples and 2 lick samples were analyzed for me by Mr. R.B. Carson, of the Analytical Chemistry Research Service, in Ottawa, to determine selenium concentrations. The results of this analytical work are shown in Table 19. All the plant samples, with the exception of buffalo berry, are in the range below .1 p.p.m. selenium. Hidiroglou (1965) found nutritional muscular disease (white muscle disease) in beef cattle where the vegetation contained less than .1 p.p.m. According to Cowan and Guiguet (1965) the mountain goat is one of the few animals which will eat buffalo berry. The sample collected at the Toby Creek lick contained .247 p.p.m. During the summer of 1966, on many occassions, goats were observed feeding on this species in the vicinity of the lick. It does not appear that the condition was alleviated due to selective feeding on buffalo berry.

Two soil samples, one from the Toby Creek lick and one from the Dutch Creek lick also contained very little selenium. It appears likely that the licks do not contain enough selenium to be effective in reducing the myopathy. Since animals entering and leaving the lick exhibit gross symptoms of paralysis, it is not likely that the licks are supplying sufficient selenium. Therefore it is unlikely that selenium is the attracting element.

Rosenfeld and Beath (1964) suggest that the incidence of the disease is higher in areas where gypsum fertilization is practiced in order to increase the yield of forage. It is interesting to note that gypsum mines are common in the area and it is not unlikely that gypsum concentrations exist in the Purcell Mountains, in the vicinity of goat range.

Table 19 Selenium values for plant samples and earth lick samples from the Purcell Mountains, on a dry matter basis.

Description of Material	Selenium in p.p.m.
Idaho Fescue	.032
Thickspike Wheatgrass	.043
Bluebunch Wheatgrass	.014
Buffalo Berry	.247
Kentucky Bluegrass	.032
Northwestern Sedge	.043
Rush (<u>Juncus parryi</u>)	.031
Alpine Strawberry	.037
Sedge Species	.029
Spike Trisetum	.016
Alpine Bluegrass	.079
Bear Berry	.030
Alpine Fir	.029
Toby Creek lick sample	.090
Dutch Creek lick sample	.038

DISCUSSION AND CONCLUSIONS

On examining the use of natural licks by goats, it appeared that patterns of movement place the animals, on a yearly basis, on ranges of differing chemical composition. The use of licks by goats in the summer is an attempt to supplement their diet in relation to the chemical nature of the ranges.

The sodium content of the forage collected at a variety of elevations is so low that it does not appear to meet the needs of the animal. In the East Kootenay, almost no information has been collected regarding the winter and summer ranges of the goat. The amount of time spent on any one range or the range they leave to move to natural licks is virtually unknown. This does not allow an estimate of the effects of a winter dietary deficiency. It appears then that the evidence presented in this thesis supports the idea that the craving is induced in the spring rather than over the winter. Observations of other ungulates wintering in the vicinity of the licks suggest that lick use occurs after feeding on spring forage high in water and low in sodium. The fact that goats do not move directly into the licks upon leaving the winter range supports this idea. At Lazy Lake a feeding period of one to two weeks preceded lick use. Goats entering the vicinity of the licks in early spring descend to low elevations to take advantage of succulent forage in region 2. Where this region is a north facing slope or at a slightly higher elevation goat activity is delayed, as is the growth of forage. The importance of the critical period in the spring is obvious and requires a more detailed examination from the standpoint of sodium content of urine, blood and forage along with water content of the forage.

As explained, females do not move to the licks until after the kidding period. It is not known whether they utilize succulent forage prior to kidding since their winter range and kidding area is not known. It does not seem likely that females are travelling extremely long distances immediately after giving birth. If the use of succulent forage is as important as suggested, females would be the most likely group to take advantage of it. While using region 2 females with kids ranged at progressively higher elevations, thereby taking advantage of succulent forage for at least a month. The relation of kidding, succulent forage and lick use is an interesting one that deserves attention in the future.

The population estimate given in this study is much higher than most local reports suggest. An attempt to confirm, by aerial census, the estimate of the number of goats calculated to inhabit the area between the Dutch Creek and

Toby Creek licks was unsuccessful, probably because we were unable to include the head water areas of the two drainages. It is not known whether these animals move from the head waters of the two drainages to the Toby and Dutch Creek licks in the spring or if they move from a closer winter range. It appears that they move to this alpine range on leaving the licks in the fall. The winter range would appear to be the key factor in determining movement to the licks, since animals move to the licks immediately after the snow recedes.

Patterns of movement have been examined in relation to populations, groups and individuals. Marking at the Toby Creek lick has shown that frequent trips are made between region 2 and 3. At both the Toby and Dutch Creek licks females travel longer distances to the licks than do males, and make the trip less frequently. Females used the Dutch Creek lick only during peaks in temperature and had to travel five to ten times farther than did the females using the Toby Creek lick. At Toby Creek the correlation between female use and temperature is very poor. It is not known at this time how important distance is in regulating movement between storms. Male use was correlated with temperature and storms in May at the Toby Creek lick although the distance between region 2 and 3 is very short. The storms at this time are severe and may overbalance the short distance. Until the exact boundaries of ranges can be delineated, the importance of distance in regulating movement between storms and frequency of use can not be determined.

During the summer, goats select to a very high degree, the trails they use moving to and from the licks, the actual lick they use and within a lick, certain sites are preferred over others. It can not be overemphasized that goats very seldom wander through the timber and that they use the trails between region 1, 2 and 3 to maximize their efficiency of movement. Due to the long distances they must often travel to reach a lick and the variety of terrain they must traverse, it can be seen that trail systems are advantageous for their survival. In this regard, region 2 is very important. Upon reaching the vicinity of a lick, region 2 provides the animal with food and escape terrain and serves as a base from which the animal can utilize the lick or escape the effects of a storm.

Goats appear to be able to tell the difference between licks and will select the one having the highest sodium concentration. In three instances the secondary lick was more accessible but was bypassed in preference for the primary lick. Within a lick, selectiveness for specific sites appears to be quite high and at three licks examined sodium was the only element consistently higher in preferred sites.

It has been shown that sodium is deficient in the forage available to goats at three elevations and at two seasons of the year. Evidence suggests that this element is available to the animals in sufficient quantities in the licks studied, to act as a supplement. Due to lack of data regarding sodium concentrations in the urine, serum sodium levels could not be used to indicate a deficiency in the animal. Since studies on other animals suggest that serum sodium can vary independently from the craving exhibited, it is quite possible that this is the case with the goat.

It appeared that white muscle disease may be present in certain populations of goats in the area. According to Muth and Allaway (1963) this is a possible selenium deficient area. While in the vicinity of the lick goats eat buffalo berry, although it is known that very few other ungulates will do so. Since this forage contained rather high amounts of selenium the selective feeding behaviour of the goat may be an attempt to reduce this deficiency. The goat winters at high elevations where this species of forage is relatively scarce and therefore unavailable for much of the year. Feeding on vegetation low in selenium has been known to directly cause white muscle disease.

LICKS AS A MANAGEMENT TOOL

One of the first uses of natural licks as a management tool should be to supply ungulates with desired nutrient material that is known to be deficient in the area. This should be accomplished without increasing the attractiveness of the lick or its concentrating power.

In the study area, selenium is thought to be deficient. It seems probable that this element could be supplied to the animals as sodium selenate, by placing small quantities in high licking sites so that it would be ingested while the animal is eating the clay soil. Similarly, phosphorus, which becomes deficient in the vegetation during the winter, could be impregnated into lick soils for those species wintering in the vicinity of natural licks.

SALTING

Whether or not to include a salting program as a part of management is difficult to answer. It has not been clearly demonstrated that the absence of supplementary sodium chloride has ill effects on animals any more than it has been proven that its presence is beneficial.

Altmann (1952) found that artificially supplied salt does not influence elk migration to any great extent in free ranging elk. Natural licks are often determinants of elk movements in local areas. The most promising employment of salting, then, seems to be the fulfillment of physiological needs and as a technique for securing proper distribution of range use. Literature available indicates that significant redistribution of big game through the use of salt has been attained only in isolated situations, and then only by very carefully executed programs. In Oregon, it is stated that after three years of experimental work, salt has not been proven to be necessary or particularly encouraging as a tool in deer management.

The introduction of salt, in the case of the bighorn may actually concentrate range use rather than distribute it (Smith, 1954).

Salt placed above or below the range of greatest elk activity on the winter range was little used. Such salt, even when visible was not attractive enough to cause many elk to enlarge their range to include it, (Beeman, 1957).

Since use of succulent spring vegetation occurs prior to lick use, it seems reasonable that any revegetation program could cause redistribution and control mobility in big game by reseeding succulent vegetation varying distances from natural licks. Artificial licks placed at higher elevations outside the normal winter range would appear attractive since succulent vegetation usually appears on the winter ranges first. In the study area, artificial licks could be initiated in region 2 adjacent to well used trails. This would be particularly beneficial to females which are vulnerable to early hunting seasons. In the fall, females are feeding on succulent vegetation at high elevations and travelling to licks at low elevations. Licks established in region 2 would shorten the travelling distance and keep the animals closer to escape terrain.

Not to be overlooked are the recreational values of licks for photographers and naturalists. Licks in wilderness areas may prove beneficial to the wildlife biologist in controlling cropping, to the animal as a dietary supplement and to the general public as a source of recreation.

SUMMARY

1. The use of natural salt licks by the mountain goat was examined from May, 1965 to September, 1966 in the East Kootenay region of B.C. The patterns of movement relating to lick use along with a chemical analysis of the vegetation, lick soils and blood serum for sodium, constituted an attempt to show that sodium was the attracting element.

2. The selection of sodium as the important element was based on mineral cafeterias, preference tests and logical elimination of other elements carried out by other workers.

3. Field methods, including those of trapping and marking were used to obtain serum samples and to follow movements of marked animals. Vegetation was collected according to the method of Dietz <u>et</u>. <u>al</u>. (1962) and soil samples were obtained from designated sites after observing the licking activity of goats.

4. Laboratory procedures included those of Chapman and Pratt (1961) for the determination of sodium and potassium in forage, those of Stockstad (1953) and of the Association of Official Agricultural Chemists (1960) for sodium, calcium, phosphorus and cobalt in soils.

Blood serum was analyzed for sodium in the Kimberley and District Hospital and the analysis for selenium was carried out by the Chemistry Research Division in Ottawa.

5. At each lick in the study area animals utilized regions 1, 2 and 3. Region 1 is the summer range the lick serves, region 2 is the base from which animals move to the lick and region 3 is the lick itself.

6. Animals were very definite in their use of trails, wandering very little and each lick had its own trail system.

7. Goats used the licks from May to September depending on the elevation of the lick and during this time encountered such additional risks as joint use, parasites, predators and hunting pressure.

8. The seasonal pattern of movement in the area is such that goats move from higher to low elevations in the spring while other ungulate species are moving from low winter ranges to higher summer ranges.

9. As the snow receded and the vegetation became green, licks at low elevations or those on south facing slopes were utilized. The use of licks at higher elevations began later in the spring.

10. Use of licks by males in the spring was preceded by a period of feeding on succulent vegetation. This suggested that initiation of use was due mainly to a high water uptake on a low sodium diet rather than a winter dietary deficiency.

11. As goats used the licks during the summer they fed at progressively higher elevations in region 2 and therefore had longer distances to move to the lick.

12. Within this period of seasonal use, male use of licks preceded female use differentially in time. It was thought that female use was delayed due to kidding.

13. Differential use occurred to some degree at four licks, however there was a difference between high and low elevational licks.

14. Grouping was consistent with the behaviour of the animals as male groups were smaller than female groups.

15. Total group size and especially female group size corresponded to group size on summer range as given by Brandborg (1955).

16. Observations on females in the lick showed the following dominance hierarchy: females with kids, females without kids and yearlings. On one occasion females showed dominance over males but encounters were too few

to draw conclusions.

17. The pattern of molt coincided with differential use, with males and females without young and females with young molting in that order. It appeared that abrasion by vegetation greatly affected molt.

18. Goats were most often observed in the licks in the afternoon while the morning and evening periods were usually spent feeding.

19. Animals were more often observed in the lick as the summer progressed and it appeared that the longer distances being travelled at this time regulated the amount of licking and frequency of trips.

20. Marking served as a basis to estimate the length of stay in the vicinity of the lick, the frequency of visits and the importance of region 2.

21. The movement of goats between regions 2 and 3 is largely controlled by storms and does not appear to be correlated with the temperature except when storms and low temperature occur simultaneously.

22. It appeared that approximately four changeovers of animals occurred at the Toby Creek lick during the summer. This allowed us to estimate that approximately 70 animals were using the lick.

23. The vegetation in the area contained very little sodium and no apparent trend existed from spring to fall or among elevational regions.

24. Analysis of the lick soils suggested that preferred licks had a higher sodium content than did less preferred ones and within a lick, high licking sites had a higher sodium content than did low licking sites. Calcium, cobalt and phosphorus did not exhibit a similar trend.

25. Blood serum, analyzed for sodium, did not reveal a deficiency in the animal. At the supposed levels of deficiency serum sodium was not useful in determining sodium as the attracting element since it was too highly regulated.

26. Animals which died during trapping operations exhibited gross symptoms attributed to white muscle disease. Analysis of the vegetation and lick soils suggested that selenium was present in amounts causing the myopathy.

27. Licks may serve as a useful management tool. Elements deficient in the area, could be placed in high licking sites so that animals could supplement their natural diet.

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APPENDIX A.

SCIENTIFIC AND COMMON NAMES FOR PLANT SPECIES MENTIONED

References include: Hitchcock (1950), Lyons (1956), and Forest Service (1937).

Grasses and sedges:

Agropyron dasystachyum thickspike wheatgrass

Agropyron spicatum bluebunch wheatgrass

Calamagrostis rubescens pine grass

Carex concinnoides northwestern sedge

Carex spp. sedge

Festuca idahoensis Idaho fescue

Koeleria cristata June grass

Poa alpina alpine bluegrass

Poa pratensis Kentucky bluegrass

Stipa columbiana subalpine needlegrass

Stipa richardsonii Richardson needlegrass

Trisetum spicatum spike trisetum

Forbs:

Fragaria glauca strawberry

Shrubs and trees:

Abies lasiocarpa alpine fir

Amelanchier alnifolia Saskatoon berry

Arctostaphylos uva-ursi bear berry

Juniperus scopularum Rocky Mountain juniper

Populus tremuloides trembling aspen

Pseudotsuga menziesii Douglas fir

Salix spp. willow

Shepherdia canadensis buffalo berry

Vaccinium scoparium grouse berry