Forage and Serum Phosphorus Values for Bighorn Sheep[1]

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Highlight

Total phosphorus values were determined monthly for winter and summer range forages in the East Kootenay Region of British Columbia. Phosphorus was high in succulent growing forages from both ranges but declined during the seed head and cured stages. The major decline for phosphorus in winter range forage was 57.1% during late summer. Serum inorganic phosphorus values for bighorn sheep were between 4.73 and 5.08 mg percent during the winter period, when plant phosphorus was between 500 and 800 ppm.

The annual cycle of phosphorus in native range plants used by domestic livestock has been reported upon by Watkins (1943); Watkins and Knox (1945); Knox et al. (1941); Johnston and Bezeau (1962); and Johnston et al. (1968). Watkins and Knox (1945) and Knox et al. (1941) have related serum inorganic phosphorus values in range cattle to phosphorus content of the forage. They indicate that phosphorus requirements are met only during the growing period.

The phosphorus requirements of bighorn sheep (*Ovis canadensis canadensis*) vary throughout the year similar to that described for domestic animals. Thus, the requirements change as an animal proceeds through an annual cycle (the growing and/or fattening period during May through October, the breeding period in November and December and the gestation and lactation period for some of the females during December through July). There has been increasing speculation concerning the adequacy of ranges to provide phosphorus during the gestation and lactation period of the annual cycle

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FIG. 1. An imprinted bighorn lamb used to determine food habits.

FIG. 2. Typical alpine range used by bighorn sheep.

(Demarchi, 1968; Watkins, 1937; Johnston et al. 1968).

This paper examines the relation between serum and forage phosphorus during the winter and gestation periods using requirement values established for domestic animals.

Methods

These results are taken from a larger study which analyzed the benefits of altitudinal migration to a bighorn sheep population. One group of sheep was maintained on winter range forage year-round (control) while the other was shifted from winter to summer and back to winter range forage (experimental) in order to simulate the natural migratory pattern. The control group contained two yearling females while the experimental group contained two yearling females and a yearling male.

Species composition of the formulated natural diets was determined from food habit studies taken from the literature, field selectivity trials using an imprinted bighorn sheep (Fig. 1), selection trials under controlled conditions in the pens and availability of the most important species as determined from the species composition of the ranges. Phenology was related to cutting date.

Samples were taken each month from each diet and analyzed for total phosphorus by the Bray P_1 method by Mr. B. Von Spindler of the Department of Soil Science at the University of British Columbia.

Serum inorganic phosphorus was determined monthly on the two groups of sheep from September 1969 to May 1970. Serum phosphorus determinations were conducted by Dr. A. Franzman of the University of Idaho by the unitest method, prepared by the Unitest Chemical Company and are reported as mg/100 ml of blood or mg percent.

Table 1. Seasonal changes in the phosphorus content (ppm) of winter and summer range forages.

Range	Date of forage collection	Total phosphorus	Decline between collection periods (%)
Winter	April 5–10	2500	
Winter	April 15–20	2600	
Winter	May 10–15	2100	19.2
Winter	May 15–25	1900	9.5
Winter	July 1–7	1500	21.0
Winter	July 10–20 to Aug. 10–20	1400	6.6
Winter	Sept. 15–20	600	57.1
Winter	Oct. 9	800	
Winter	Oct. 10	600	
Winter	Oct. 15	800	
Winter	Oct. 20–25	600	
Winter	March 6–30	500	
Total			81.0
Subalpine	July 1–7	1700	
Alpine	July 10–15	3000	
Alpine	Aug. 10–20	3000	
Alpine	Sept. 20–25	1300	
Alpine	May 18	1300	
Maximum to minimum			56.6

Results and Discussion

Phosphorus values, in Table 1, serve to describe the annual cycle for some of the most important range species of the East Kootenay Region, B. C. A comparison of the

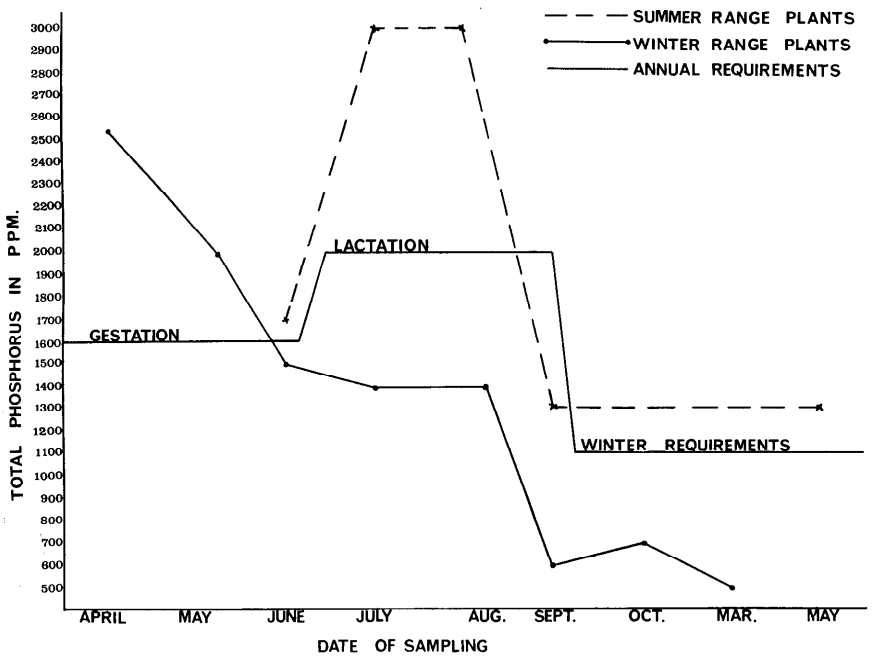

FIG. 3. The annual cycle of total phosphorus in winter and summer range plants, 1969–70.

values obtained from the winter ranges and alpine summer ranges (Fig. 2) is depicted in Figure 3. The samples upon which these comparisons are made were taken monthly between April 1969 and March 1970.

The phenological stage at each cutting date is presented in Tables 2 and 3 along with the approximate forage and percent composition of each diet. Bluebunch wheatgrass (*Agropyron spicatum*) comprises at least 75 percent of each winter range diet collected between April and September 20 as well as that cut during March 6–30. The diet cut October 9 contained only 50 percent bluebunch wheatgrass. The remaining portion of each of the above grass diets consisted of fescue (*Festuca* spp.), Junegrass (*Koeleria cristata*), pinegrass (*Calamagrostis rubescens*) and needlegrass (*Stipa* spp.). These species formed the grass portion of the diet when no bluebunch wheatgrass (October 10 and 15) was present. A diet consisting of mainly Kentucky bluegrass (*Poa pratensis*) was collected during October 20–25.

The presentation of diets in this order allowed a preliminary examination of the potential of bluebunch wheatgrass to supply phosphorus to a wild ungulate.

The subalpine and alpine mixtures were categorized only as grasses and sedges, forbs and shrubs (Table 3).

Maximum phosphorus valucs of winter range grasses, mainly bluebunch wheatgrass and fescue, reached 2600 to 2800 ppm in April but had declined to 1600 ppm by early July. Decline was abrupt between July and September, with a total decline for the period of about 57%. Late winter values of 500 ppm represented about an 81% loss from maximum values, the previous spring. Declines are minimal from early to late winter, during the period when forage is frozen. The phosphorus content of the grass mixtures fed during this period ranged between 500 and 800 ppm. There appeared to be no significant differences in the phosphorus content, between diets, as the quantity of bluebunch wheatgrass declined from 75% to 0.

The alpine forage, with its later commencement of growth, reached maximum levels toward the end of July (3000 ppm) and maintained these throughout August. By freeze-up in late September values had declined by 56% to 1300 ppm. The May value represents the year-old growth as first exposed after snow melt in the spring or as taken from beneath the snow cover. The much reduced decline during winter freeze-up is comparable to that found on the winter range. In September, the phosphorus values of alpine vegetation are about twice those of the corresponding winter range vegetation and during late winter they are two to three times greater. The maximum levels of phosphorus in alpine forage and seasonal declines, encountered in this study, were similar to those found by Johnston et al. (1968), working in Alberta.

Table 2. The approximate phenology and composition (%) of the natural diets cut on the Premier Ridge winter range.

Date of forage collection	Approximate phenology	Composition of diet		
		Grass	Forbs	Browse
April 5–10	New growth	100	0	0
April 15–20	New growth	99	.5	.5
May 10–15	Third leaf	90.9	8.2	.9
May 15–25	Fourth leaf	94.7	0	5.3
July 1–7	Seeds ripe	88.2	7.1	4.7
July 10–20 to Aug. 10–20	Seeds shedding	88.1	7.2	4.7
Sept. 15–20	Cured	90.0	7.0	3.0
Oct. 9	Cured	95.0	4.0	1.0
Oct. 15–20	Cured	90.1	6.8	3.1
Oct. 20–25	Cured	92.0	2.0	6.0
March 6–30	Over-wintered	95.0	2.0	3.0

Table 3. The approximate phenology and composition (%) of the natural diets cut on subalpine and alpine range.

Date of forage collection	Area	Approximate phenology	Composition of diet		
			Grass & sedge	Forbs	Browse
July 1–7	Subalpine	Late leaf to flower	41.7	50.4	7.9
July 10–15	Alpine	New growth	49.3	50.7	0
Aug. 10–20	Alpine	Flower to seed stage	56.4	34.8	0
Sept. 20–25	Alpine	Plants frozen	85.0	15.0	0
May 18	Alpine	Over-wintered	50–60	40–50	0

As shown in Figure 3, the minimum level required for gestating domestic ewes is 1600 ppm or .16%, as set by the National Research Council (1964). They suggest that lactating ewes require .20% phosphorus. Watkins (1943) gives .093% as the minimum winter requirements for range cattle.

Winter range forage meets the phosphorus requirements for gestation during the latter half of the gestation period. It appears inadequate during lactation. If bighorn ewes migrate to alpine areas during lactation, they appear to receive adequate phosphorus. The alpine summer range provides adequate amounts of phosphorus for winter requirements (certain bands of bighorn sheep remain on alpine ranges year-round) whereas the winter range does not.

Blood sampling began October 1, 1969, and was performed monthly until May 1970. Serum phosphorus values for this period are given in Table 4.

The initial blood sample was taken on October 1 while the experimental group was on alpine forage and the control group on winter range forage. The experimental group showed a serum phosphorus value of 6.26 mg percent while on forage containing 1300 ppm phosphorus. The control group showed a value of 6.64 mg percent while on forage containing 600 ppm phosphorus. Thus, although forage phosphorus differed by about 54 percent serum phosphorus values were similar, averaging 6.45 mg percent.

During the winter months, both groups subsisted on winter range forage containing 500 to 800 ppm phosphorus. Serum phosphorus declined to 5.08 and 4.73 mg percent for the experimental and control groups, respectively. Simesen (1963), states that serum inorganic phosphate concentration in normal adult animals is 4–7 mg/100 ml.

During early spring (May, 1970), both groups were placed on an artificial pelleted ration (ration 36–57) containing 6600 ppm phosphorus. Serum inorganic phosphorus rose to an average of 9.95 mg percent (Table 4).

There appears to be a direct relationship between serum and forage phosphorus during the winter months. According to the correlation coefficient of .885 the variables are significantly related ($P = .0015$). Knox et al. (1941) gives a correlation of $.6102 \pm .0646$ between forage and serum phosphorus of cattle, during an annual cycle, indicating the usefulness of this relationship in the assessment of the phosphorus nutrition of an animal.

Kleiber et al. (1936) shows that cattle on a high phosphorus diet have high serum phosphorus levels (8.27 to 9.79 mg percent) and low serum phosphorus values (3 to 5 mg percent) on a low phosphorus diet.

Franzmann and Thorne (1970) give a serum phosphorus value of 3.9 ± 1.1 mg percent for 6 bighorn sheep captured in Wyoming during March. This value is only slightly below that obtained in this study (5.10 mg percent) during the same month. According to Long et al. (1965) and Knox et al. (1941) serum inorganic phosphorus is slightly higher in young animals, which may account for the difference between my sheep and those of the above authors.

Conclusions

The alpine ranges supply sufficient quantities of phosphorus year-round according to the requirements of domestic animals. Although scattered populations of bighorn sheep remain on these ranges throughout the year it is unlikely that herd numbers can be increased on these ranges during the winter months. The adjacent winter range appears adequate only during the growing period (April to July). Also, bluebunch wheatgrass did not provide significantly greater quantities of phosphorus

Table 4. Monthly serum inorganic phosphorus values (mg/100ml) for the control and experimental groups, 1969–70.

Date of blood sampling	Date of forage collection	Serum phosphorus	
		Control group	Experimental group
Oct. 1	Sept. 15–20	6.64	6.26
Dec. 3	Oct. 9	3.63	3.90
Dec. 29	Oct. 10	4.35	5.50
Jan. 19	Oct. 15	5.05	4.80
Feb. 11	Oct. 20–25	5.60	5.80
March 4	Oct. 20–25	5.50	4.70
April 13	March 6–30	4.30	5.80
May 20	Ration 36–57	10.30	9.60
N.		14	21
Mean (not incl. ration 36–57.)		5.04	5.25
S.E.		±1.3	±.7

than any of the other grass mixtures when collected in the cured stage.

Since aphosphorosis did not occur during the winter blood sampling period, phosphorus accumulated during the growing period on winter and alpine ranges may influence blood phosphorus during the winter when forage phosphorus is in short supply. At this time it is not known to what degree a free-ranging animal can accumulate phosphorus (April to October) nor the ease with which it is mobilized from storage depots. Simesen (1963) states, "Bone mineral is readily mobilized to maintain the level of serum calcium, but less readily to maintain that of phosphorus, so that a low serum inorganic phosphate level is the first sign of a deficiency of phosphorus." Hays and Swenson (1970) suggest that bone phosphorus is readily mobilized.

Serum inorganic phosphorus levels of my sheep did not indicate a state of deficiency. They were above 4 mg/100 ml, the minimum level set by the National Research Council (1964) and Watkins and Knox (1945).

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