Selenium Concentrations in Forage on Some High Northwestern Ranges[1]

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Highlight

Forages produced on some high northwestern ranges were analyzed for selenium concentration to determine the hazard of white muscle disease (WMD) in calves and lambs. The selenium concentration in 94 forage samples ranged from 0.01 to 0.78 ppm, of which 20 samples contained more than 0.10 ppm. The remaining 74 samples contained less than 0.10 ppm and 59 of those contained less than 0.05 ppm. Approximately 90% of the summer ranges studied produce forage containing less than 0.10 ppm selenium. Thus, the hazard of WMD on these northwestern ranges may be high. Ranchers should work individually and in groups to ascertain losses from the disease and minimize them by injecting the animals with selenium.

Livestock losses from selenium responsive diseases are common in the northwestern United States. White muscle disease (WMD), the most common of these diseases, afflicts calves and lambs, causing serious economic losses. WMD occurs when animal feeds contain insufficient selenium for normal animal nutrition (Muth, 1963). The minimal diet level of selenium required to prevent WMD is from 0.03 to 0.10 parts per million (ppm), depending upon the level of vitamin E and possibly other substances (Allaway et al., 1967; and Underwood, 1966). While range forage is still green, it contains a good supply of vitamin E and the required selenium content to prevent WMD is below 0.10 ppm and may be as low as 0.03 ppm. As the range forage dries, the selenium content required to prevent WMD increases to about 0.10 ppm. WMD is common in animals being fed hay that contains less than this amount.

Animals on high selenium diets for a few months build up selenium reserves that may protect them and their offspring from WMD for a full year. Thus, the selenium content of feed being consumed by livestock during all seasons should be known. Low selenium diets at a certain time may not represent a WMD hazard if animals have built-up protective reserves from a previous diet. The duration of these selenium reserves depends on the concentration in the diet and how long the animals are on that diet.

Generally, only animals less than six months old are afflicted by WMD. The disease is characterized by muscle tissue degeneration, and the animal may or may not exhibit visible symptoms, depending on the muscles that are affected. Heart muscles are most commonly affected, and animals may exhibit no symptoms until death. Other muscles commonly affected are hindquarter, forequarter, and throat muscles. When these muscles degenerate, the animals have difficulty walking, standing, or swallowing. Often the degenerating muscle tissue contains white deposits of calcium compounds. Hence the name—white muscle disease.

Plants may contain from none to several thousand parts per million of selenium, depending upon the plant species and the soil. On alkaline soils, certain plants may accumulate concentrations toxic to livestock. Toxicity usually results from eating plants containing from four to several thousand parts per million selenium (Rosenfeld and Beath, 1964). Extensive information is available about selenium toxicity to animals and the geographic regions where selenium toxicity is likely are also well characterized.

A map showing the selenium concentration in forage and hay crops produced in broad general areas is available (Kubota et al., 1967). Alfalfa was the primary plant sampled for this map, and high rangeland samples were not included. A more detailed map showing selenium concentration in forage and hay crops in the Pacific Northwest was published later (Carter et al., 1968), but again alfalfa was generally the plant sampled. This latter study did include samples from three high ranges, however. The data from these three ranges indicated

[1] Received July 16, 1969; accepted for publication September 15, 1969.

that forage on some high northwestern ranges may be low in selenium content.

Methods

Sampling locations were selected on high northwestern rangelands used for summer and early fall grazing. The locations selected represent large areas typical of the particular high range. These ranges are generally conifer-aspen-grass or conifer-grass complexes. Mixed forage being consumed by livestock was sampled at each location. At most sites the samples were composed of 4 to 8 different plant species. The relative proportions of the various species were not determined because the primary objective was to sample the forage being consumed by the livestock. Each sample was composed of clippings of mixed forage from at least 20 different plants or plant clusters. Generally, the samples were composited from plants sampled over more than one acre. Care was taken to avoid sampling plants and areas that might have been contaminated by construction activities or excessive animal activity.

The samples were placed in cloth bags, taken to the laboratory, dried at 50 C for at least 48 to 72 hours, and ground to pass through a 1-mm sieve. The selenium content was determined fluorometrically by the method of Allaway and Cary (1964).

No selenium accumulator plants grow in any of the high elevation areas sampled. However, to assure that mixed species samples represented the true selenium content of all forage in the area, samples of several individual species were collected at some sampling sites. The selenium contents of different species at the same site were very nearly the same. Differences were generally within the margin of experimental error of the analysis procedure. These results agree with a report that the selenium concentration of non-accumulator species will be nearly the same on low selenium soils (Ehlig et al., 1968). Thus, even if animals selectively grazed, they would obtain about the same quantity of selenium as they would from random grazing.

Results and Discussion

The selenium content of 94 forage samples from high northwestern ranges varied from 0.01 to 0.78 ppm, but only 20 samples contained more than 0.10 ppm. The remaining 74 samples contained less than 0.10 ppm selenium. Of these 74 samples, 59 contained less than 0.05 ppm. Thus, forage produced on many high summer ranges in the northwestern U.S. is low in selenium concentration, and livestock losses from WMD and other selenium-responsive diseases may occur on these rangelands.

The high rangelands sampled were grouped into 14 areas according to geographic location (Fig. 1). Each range area was then classified according to the selenium level found in the forage sample (Table 1). Where 75% or more of the samples contained more than 0.10 ppm selenium, the area was classified as adequate in selenium, even though it is realized that some ranges in this group may have localized areas of inadequate selenium in the forage. Where 75% or more of the samples contained

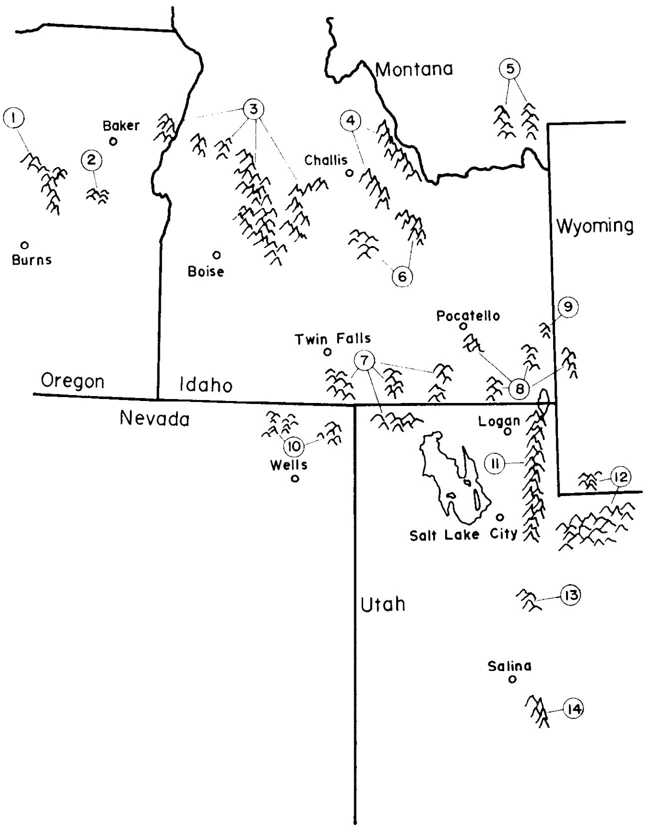

FIG. 1. Geographic location of high northwestern ranges where forage was sampled for determining selenium content.

less than 0.10 ppm selenium, the area was classified low or very low in selenium level depending upon the proportion containing less than 0.05 ppm selenium. Areas not falling in the described groupings were classified as variable in selenium level. Some information on the geologic materials and the soil associations present in each area is also given in Table 1 (Ross and Forester, 1947, and Western Land Grant Universities and Colleges and the Soil Conservation Service, 1964).

Areas 1, 6, 9 and 13 produce forage that generally contains adequate selenium for animals. Area 1 is north of Burns, Ore., and lies within an area where Carter et al. (1968) found that alfalfa at lower elevations contained adequate selenium. Thus, both high elevation summer forage and hay used for winter feed contains sufficient selenium to protect livestock from WMD. This range was the largest summer range sampled that produced forage containing adequate selenium. Area 6 comprises the Big and Little Lost River drainages in Idaho, including the important Copper Basin range. This area also lies within an area where alfalfa grown at lower elevations contained adequate selenium. Area 9 is on a mountain range containing phosphate deposits known to contain considerable selenium (unpublished data of au-

Table 1. Selenium concentration in forage from high summer ranges. Area locations are shown in Fig. 1.

Area	States	Counties	National forests	Elevation (ft) of samples	Number of samples by selenium concentration (ppm) ranges			Selenium level
					0–0.5	0.05–0.10	>0.10	
1	Oregon	Baker	Malheur	5000– 5500	1	1	6	Adequate
2	Oregon	Harney	Willowa-Whitman	5260– 6000	1	1	0	Low
3	Oregon Idaho	Baker Washington Adams Valley Custer Elmore Camas	Willowa- Whitman Payette Boise Challis Salmon	5000– 7250	11	2	1	Very low
4	Idaho	Lemhi Custer	Challis Salmon	7000– 8300	1	1	0	Low
5	Montana	Madison	Beaverhead	7000– 8000	6	0	0	Very low
6	Idaho	Custer	Challis	7000– 8000	0	0	2	Adequate
7	Idaho	Twin Falls	Sawtooth	7000–10000	17	3	2	Very low
8	Idaho Wyoming	Power Franklin Bear Lincoln	Caribou Bridger	5500– 7200	2	2	0	Low
9	Idaho	Custer	Caribou	7500	0	0	1	Adequate
10	Nevada	Elko	Humboldt	5000– 8000	3	0	1	Low
11	Utah	Cache Weber Davis Salt Lake	Wasatch Cache	6750– 8600	2	2	1	Low
12	Utah Wyoming	Summit Uinta	Wasatch Uinta Ashley	7000–10000	6	1	0	Very low
13	Utah	Utah	Uinta	7000	0	0	1	Adequate
14	Utah	Sevier	Fishlake	8000–10000	9	2	5	Variable
				TOTAL	59	15	20	

thors). The sample from area 9 contained 0.78 ppm selenium, the highest found in the study. Area 13 is part of the Uinta National Forest south of Payson, Utah. Areas 9 and 13 lie within areas mapped variable by Carter et al. (1968). Thus livestock grazing summer ranges may or may not obtain adequate diet selenium for part of the year on these areas, depending upon the selenium content of winter feed.

Area 14 was the only range classified as variable. On this range, 69% of the samples contained less than 0.10 ppm selenium. Livestock losses from WMD in that area depend upon where the stock graze, supplement feeding programs and the selenium content of hay feed on home ranches. The WMD hazard is fairly high in area 14.

Five range areas produce forage classified as low in selenium level. These are areas 2, 4, 8, 10, and 11. Area 2 is south of Baker, Oregon in the Willowa-Whitman National Forest. Area 4 represents two ranges east of Challis, Idaho. Area 8 includes most of the high range in the southeastern corner of Idaho. Area 10 is the high range in northeastern Nevada, and area 11 is the Wasatch Mountain range in Utah. Livestock grazing forage on these ranges may not obtain adequate selenium to protect young animals from WMD.

The remaining four range areas produce forage very low in selenium content. Area 3 includes a vast area north of Boise, Idaho which extends into Oregon. Area 5 is in southern Montana, and it lies within a region where alfalfa grown at lower elevations is also low in selenium (Carter et al., 1968). Area 7 includes portions of the Sawtooth National Forest in southern Idaho and Northern Utah. Area 12 is the Uinta Mountains in Utah with one sample from Wyoming.

Ranges producing low and very low selenium forage represent approximately 90% of the grazing area studied. Only a small portion of the rangeland

Table 2. Geologic materials and soil associations for the sampling areas.

Area	Geological materials present	Soil associations present
1	Jurassic and Triassic rocks. Columbia River basalt.	Soils of the cool to cold subhumid and humid forested regions (F). Western Brown Forest, Regosol and Lithosol (F 14).
2	Columbia River basalt. Jurassic and Triassic rocks. Carboniferous rocks.	Soils of the cool to cold, subhumid and humid forested regions (F). Western Brown Forest, Regosol and Lithosol (F 14).
3	Columbia River basalt. Jurassic and Triassic rocks. Granitic rock of the Idaho Batholith. Permian sedimentary rocks.	Soils of the cool to cold, subhumid and humid forested regions (F). Brown Podzolic, Lithosol and Regosol (F 2) and Western Brown Forest.
4	Belt age argillites and quartzites. Paleozoic sedimentary rocks.	Dark colored soils of the subhumid regions (D). Prairie, Gray Brown Podzolic and Western Brown Forest (D 8).
5	Permian, undifferentiated, chert sandstone, limestone, quartzite and shale. Pre-Belt gneiss, schist and related rock.	Dark colored soils of the subhumid regions (D). Chernozem, Prairie and Lithosol (D 4).
6	Paleozoic sedimentary rocks, undifferentiated. Challis volcanics.	Dark colored soils of the subhumid regions (D). Prairie, Gray Brown Podzolic and Western Brown Forest (D 8).
7	Snake River basalt, Idavada volcanics. Belt series argillites and quartzites. Some granitic rocks.	Dark colored soils of the subhumid regions (D). Prairie, Gray Brown Podzolic and Western Brown Forest (D 8). Prairie, Gray Wooded, Chestnut and Lithosol (D 10).
8	Mesozoic sedimentary rocks. Paleozoic sedimentary rocks. Alluvial and glacial deposits.	Dark colored soils of the subhumid regions (D). Chenozem, Chestnut and Prairie (D 2). Prairie, Gray Brown Podzolic and Western Brown Forest (D 8).
9	Mesozoic sedimentary rocks.	Soils of the cool to cold, subhumid and humid forested regions (F). Gray Wooded, Gray Brown Podzolic, and Western Brown Forest (D 9).
10	Idavada volcanics and silicic rocks of volcanic origin.	Dark colored soils of the subhumid regions (D). Prairie and Lithosols (D 11).
11	Knight Conglomerate, chiefly fluvial Ordovician rock. Nounan formation limestone and dolomite. Brigham Quartzite formation.	Dark colored soils of the subhumid regions (D). Prairie, Gray Wooded, Chestnut and Lithosol (D 10).
12	Mississippian rocks, undivided Early Tertiary, andesitic and pyroclastic rocks. Alluvial deposits. Mutual Formation, chiefly quartzite.	Soils of the cool to cold, subhumid and humid forested regions (F). Gray Wooded, Podzol, and Lithosol (F 10).
13	Early tertiary andesitic and pyroclastic rocks.	Dark colored soils of the subhumid regions (D). Prairie, Gray Wooded, Chestnut and Lithosol (D 10).
14	Late Tertiary basalt and basaltic andesite flows, Tertiary volcanic rocks, undifferentiated. Glacial outwash.	Dark colored soils of the subhumid regions (D). Prairie, Gray Wooded, Chestnut and Lithosols (D 10).

produces forage with adequate selenium to assure protecting livestock from WMD. Therefore, the hazard for livestock losses from WMD on these western ranges may be high. However, actual losses may not be great on all these ranges because of high vitamin E content of green forage, and other factors.

Incidence of WMD in calves and lambs is related to the supply of selenium to the mother before the calves and lambs are born. There is some lasting protection against WMD when mother animals have been supplied adequate selenium. How long the protection lasts depends upon many factors such as the length of the adequate supply period and the selenium concentration in the supplying source relative to the critical protective level. Thus calves and lambs born on high summer ranges may not suffer WMD even though the forage contains insufficient selenium. Protection of young animals can also be assured by injecting the mothers with selenium during gestation (Hidiroglou et al., 1965; and Mace et al., 1962). Another way to provide protective selenium on high ranges would be by supplying selenium-fortified salt, if it were approved for use (Paulson et al., 1968).

The feed consumed by livestock during the entire year should be considered in management practices to combat WMD losses. Cattle and sheep usually are fed hay in the winter, graze low elevation ranges in the spring, graze high elevation ranges in the summer, and again graze low elevation ranges and late growth in cultivated fields in the fall. In this type of management system there are at least three sources of feed—the hay, the low elevation range forage, and the high elevation range forage. Often supplements are fed during certain times of the year. The selenium content of all these sources is important. When all feed sources are low in selenium, the incidence of WMD will likely be higher than when one or more feed source contains adequate selenium. For example, area 5 is located where all local sources of animal feed contain insufficient selenium. Losses from WMD in this area are high and ranchers inject most young animals with selenium to minimize losses. In contrast, areas 10 and 12 are within regions where lower elevation range forage and hay produced contain adequate selenium. Therefore, losses from WMD may be few, although the actual losses are not known.

The data presented in this paper indicate that most of the high northwestern ranges produce forage low in selenium content. On these ranges, calves and lambs are not assured protection against WMD and possibly other selenium-responsive diseases. Even if animals are not lost to WMD, they are not building selenium reserves to protect them or their offspring at a later time. Thus, many ranchers in the region may lose young livestock on the high summer ranges or at a later time from WMD. These losses may have occurred for many years and may be considered as part of the "natural" range losses. Where actual losses are verified, practices to minimize them will be of economic value to ranchers. The best known approved practices are to inject young calves and lambs with selenium soon after birth, or to inject pregnant animals. For cattle, the latter practice would be more expensive because selenium must be administered in relation to animal weight, but it would be more convenient than finding, catching, and injecting the young calves on the range. The most convenient and economic practice will depend upon the particular situation. Ranchers should determine the best practice for their operation and minimize losses from WMD where they occur.

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