The Abortifacient and Toxic Effects of Big Sagebrush (*Artemisia tridentata*) and Juniper (*Juniperus osteosperma*) on Domestic Sheep

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Highlight: *Big sagebrush (*Artemisia tridentata*) fed to sheep by stomach pump to study its abortifacient properties during the 2nd trimester of pregnancy produced no reproductive difficulties. However, big sagebrush was lethal when ¾ lb was fed by this method daily for 1, 2, or 3 days. Sagebrush fed ¼ lb daily and slowly increased to ¾ lb daily was not toxic. These findings confirm many general reports of suspected sagebrush toxicity and indicate the need for caution in moving sheep rapidly onto big sagebrush areas.*

*Juniper (*Juniperus osteosperma*) fed to sheep in 1 lb daily amounts in an interrupted series of feedings totaling 30 days in the 2nd and early 3rd trimester of pregnancy caused abortion in 2 sheep and birth of a weak lamb from a 3rd sheep. Attempts to confirm these findings by feeding juniper to other sheep during gestation days 60 to 90 were unsuccessful.*

Sagebrush (*Artemisia* spp.) and juniper (*Juniperus* spp.) are two of the most dominant plants on the ranges of western United States. They often occupy the same range. Big sagebrush (*A. tridentata*), which includes several sub and cross species, may be found on a variety of soil types at elevations of 2,000-10,000 feet and is heavily utilized as food by both domestic and wild ruminants. At many lower elevations sheep may graze for 5-7 months of the year on winter ranges composed almost entirely of big sagebrush (Cook et al., 1954). Another sagebrush, black sagebrush (*A. nova*), considered in many areas to be a climax plant, is highly palatable to sheep and has long been classed a valuable browse plant (Hutchings, 1954). It, thus, is sought and utilized highly by sheep. Additionally, wild ruminants, especially deer, are forced in many areas of the West to rely more and more on sagebrush and juniper as major winter maintenance plants.

Sagebrush species have long been suspected of being toxic to livestock. Authoritative evidence of toxicity is scarce, however, but many general citations over the past 70 years list its suspected toxicity. Among these, Pammel (1911) reported that Montana livestockmen suspected the toxicity of various species of sagebrush. Crawford (1908) listed a loco-like condition in stock attributed by ranchers of western states to the eating of sagebrushes. Sampson and Malmsten (1935) indicated that western stockmen attributed sickness in sheep and horses to *A. tridentata.* Beath et al., (1939) reported that sand sagebrush (*A. filifolia*) caused sagebrush sickness in horses, a condition characterized by nervousness, rapid respiration, and tendency to fall when forced to move quickly. In

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Table 1. Range of values of clinical chemical determinations on blood from sheep fed sagebrush and juniper in Experiment 2.

Test	Control	Juniper-fed	Sage-fed	Sage and Juniper-fed
Erythrocytes (× 10^6/cmm)	9.5–13.6	10.9–13.6	10.5–13.4 (17.4)[1]	10.3–14.0
Leucocytes (× 10^3/cmm)	4.4–9.9	4.6–11.1	4.4–10.5	4.6–10.5
Hemoglobin (gm %)	11.4–15.6	12.3–16.2	13.0–15.3 (21.6)	11.7–16.4
Packed cell volume (%)	36–46	38–47	38–44 (64)	36–46 (54)
Alkaline phosphatase (Sigma units/ml)	1.2–4.5	1.5–6.0	1.8–6.1	0.9–4.2
Glutamic oxaloacetic transaminase (Dade, units/ml)	60–96	72–132	68–102	60–116
Lactate dehydrogenase (Dade, units/ml)	450–950	585–1145	600–1285 (2675)	570–1110 (28,300)
Blood urea nitrogen (Sigma, mg %)	15.0–20.5	13.0–23.0	13.5–21.5 (64)	10.0–20.5 (140.0)
Total protein (gm %)	6.9–8.1	6.7–8.5	6.5–7.7	6.1–8.0 (8.7)
Albumin/globulin ratio	1.0–1.6	1.0–1.4	0.9–1.6	1.0–2.1

[1] Values in parentheses are those reached by sheep just prior to death.

present-day operations experienced and perceptive livestockmen are aware of and often refer to "sage sickness" or "sage loco" in sheep.

Similarly, juniper (*Juniperus* spp.) has the reputation of being toxic to livestock (Kingsbury, 1964). Though probably not utilized as heavily as sagebrush, it is thought to cause abortion in cattle (Norris and Valentine, 1954) as do certain of the *Pinus* species (MacDonald, 1952). However, definitive experimental evidence of juniper toxicity is not available to substantiate these suspicions.

Reported herein are experiments testing the abortifacient and toxic effects of big sagebrush (*A. tridentata*) and juniper (*J. osteosperma*) on sheep fed these plants during the second and early third trimester of pregnancy.

Materials and Methods

Experiment 1

Six sheep weighing approximately 100 lb each were bred in early January. Fresh juniper leaves and small stems were collected, finely ground, suspended in water, and fed daily to the sheep by stomach pump at the rate of 1 lb of plant per day per sheep. All sheep were fed 10 consecutive days on gestation days 65 to 75, rested 10 days, fed 10 days on gestation days 85 to 95, rested 10 days and fed finally on gestation days 105 to 115. The sheep were penned and given alfalfa hay and water free choice. Animals were observed daily for overall condition and for signs of abortion.

Experiment 2

Sixteen yearling sheep weighing approximately 100 lb each were divided into 4 groups of 4 sheep. All sheep were bred 60 days prior to the start of the experiment. The experimental plan for daily feeding to each sheep was: Group 1 (controls), alfalfa; group 2, ¾ lb fresh juniper leaves and small stems; group 3, ¾ lb big sagebrush leaves and small stems; and group 4, ¾ lb juniper and ¾ lb sagebrush. All sheep were to be fed test plants on gestation days 60 to 90. Sheep in groups 1 and 2 (control and juniper) were fed as planned. In group 3 (sagebrush), however, 3 sheep died within the first 4 days of feeding. Thus, starting at gestation day 60, 2 additional sheep were fed by the following schedule: Each was fed ¼ lb sagebrush for 2 days, then ½ lb for 4 days, and ¾ lb for 24 days. Adjustments due to toxicity were also made in the sagebrush-juniper group so that each sheep was fed ¾ lb sagebrush and ¾ lb juniper daily for 4 days, not fed for 3 days, fed ¼ lb sagebrush and ¼ lb juniper for 5 days, ½ lb of each plant for 8 days, and ¾ lb each plant for 10 days. A 5th sheep which replaced one that died on day 8 was fed similarly. In addition to test plant, all sheep in the experiment had alfalfa hay and water free choice.

Blood was obtained from each sheep 2 times within a 5-day period before plant feeding began, once each week during plant feeding, and 1 week after termination of feeding. The following determinations were made: erythrocyte (RBC) and leucocyte (WBC) counts, hemoglobin (HB), packed cell volume (PCV), alkaline phosphatase (AP),[1] glutamic oxaloacetic transaminase (GOT),[2] lactic dehydrogenase (LDH),[2] blood urea nitrogen (BUN),[1] total serum proteins (TP), and albumin-globulin ratio (A/G). RBC, WBC, HB, and PCV determinations were made to detect blood cell disorders, hemoconcentration, or infection; AP, GOT, and LDH to detect liver malfunction or tissue damage; BUN to detect kidney malfunction; and TP and A/G to determine possible protein metabolism disorders. Animals were observed daily, and tissues from animals that died were fixed in buffered formalin and stained with hemotoxylin and eosin for histopathological analysis.

Results

Experiment 1

Two sheep aborted on days 87 and 125. One sheep gave birth to a lamb with a crooked neck, which recovered in 10 days. One normal-appearing lamb was born dead, apparently due to dystocia. The remaining 2 sheep had normal lambs. Though periodic weights of the ewes were not taken, they appeared to gain weight normally and were in good condition throughout the experiment.

Experiment 2

Three control sheep had normal twins and 1 sheep had a small, weak, but normal 7-lb lamb. Three juniper-fed sheep had normal twins and 1 had a normal single lamb. In the sagebrush-fed sheep, 1 sheep fed one daily dose died on day 3; 1 sheep fed 2 consecutive days died on day 2; and 1 sheep fed 3 consecutive daily doses died on day 4. The replacement sheep, fed slowly increasing doses, each gave birth to a single normal lamb. Of the sagebrush-juniper-fed sheep, 1 had normal twins, 2 had normal singles; and the sheep that died on treatment day 8 had a single fetus, which appeared to have died before the ewe. The replacement ewe had a single normal lamb.

Surviving sheep were healthy and maintained good condition throughout the experiment.

The range of values of clinical chemical tests are tabulated by groups in Table 1. With the exception of those animals that died and were bled just prior to death, all values fell within the range of values established by the controls or by previous determinations made on normal sheep at this laboratory. Those that died, which were bled within 36 hours prior to

[1] Sigma Chemical Company, St. Louis, Missouri.

[2] Dade Chemical Company, Miami, Florida. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Dep. Agr. and does not imply its approval to the exclusion of other products that may be suitable.

death, had elevated BUN, LDH, PCV, and RBC values (Table 1).

Signs of illness in animals that died were: lethargy, cessation of rumen activity, weakness, extreme depression, frothing at the nose and mouth, and terminal recumbency.

Discussion

Experiment 1, though of a preliminary nature, seems to indicate that juniper fed in sufficient quantity to sheep between the 65th and 115th day of gestation causes abortion. However, the negative results obtained in the juniper-fed group in Experiment 2 do not substantiate that conclusion. The most notable difference between experiments is the interrupted juniper feeding schedule in Experiment 1, which extended the feeding period 25 days into gestation and thus into the third trimester of pregnancy. Abortions in the bovine due to the ingestion of needles from ponderosa pine are generally confined to the third trimester of pregnancy. Possibly toxins in juniper may be closely related to those in pine and interference with pregnancy likewise may be expected only in the third trimester.

The sagebrush-juniper Experiment 2 was designed to give experience in feeding these plants to sheep prior to testing their effects on mule deer. Thus, the 60-90 day period of gestation was chosen as a time corresponding most closely to that period of pregnancy when deer in Utah were ingesting sagebrush and juniper at the highest rate. Another feeding period might have produced reproductive difficulties more effectively.

The high degree of toxicity of sagebrush to sheep in Experiment 2 was unexpected, and was almost certainly related to the sudden high exposure to the ground plant without first preconditioning the sheep by feeding smaller amounts. However, the experiment does indicate that big sagebrush contains substances which are highly toxic to sheep. Furthermore, sheep can tolerate 20-25% of their daily diet of sagebrush if given a reasonable period to adjust. It also suggests that sheep being trailed or moved from range to range could ingest sufficient sagebrush to induce toxicity if they were moved quickly onto a range that was predominantly sagebrush.

Apparently the principal acute lesion was a severe necrotizing rumenitis which can develop quickly and elicit systemic shock. Associated histopathologic changes will be reported elsewhere.

Because of the acute nature of the toxicity, the clinical chemical tests were ineffective in predicting the onset of symptoms, but the normal values obtained throughout the experiment in those animals which tolerated the full 30-day plant feeding trial indicated that there was probably no chronic tissue damage. This further supports the proposal that systemic shock probably caused mortality. Additionally, serious systemic disturbances would have increased the likelihood of interrupting pregnancy, which did not occur. This experiment, thus, offers no clues as to any abortifacient properties big sagebrush may have but does confirm the suspicions of many perceptive livestockmen that sagebrush, when consumed at certain times or under certain conditions, is toxic to sheep. It is recognized that domestic as well as wild ruminants are selective, if allowed, in their grazing of sagebrush and that toxicity of sagebrush may vary greatly within species or varieties and perhaps with stage of growth of the plant and time of year. The influences of these variables are being investigated.

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