Management Practices to Reduce Lupine-Induced Crooked Calf Syndrome in the Northwest

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On the Ground

- Lupines are legumes and may provide a source of protein and other nutrients late in the growing season. However, toxins are concentrated in the pods and will poison animals, especially sheep, if gluttonous consumption occurs.
- Risk of lupine-induced crooked calf syndrome depends on multiple factors including lupine population density, availability of other quality forages, weather/climate patterns, breeding schedules, stage of pregnancy, grazing management strategies, and others.
- Using stockers, open heifers, or other livestock species to graze lupine-infested pastures is one way to utilize high-risk rangelands. Do not overgraze as animals may be poisoned if forced to subsist on lupines.
- Identify lupines and obtain a chemical analysis for risk assessment on rangelands before turning pregnant cows out. Plant samples may be submitted to the USDA–Agricultural Research Service Poisonous Plant Research Laboratory for identification, chemical analysis, and a follow-up risk assessment at no charge. Contact kip.panter@ars.usda.gov.

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Crooked calf syndrome (CCS) is a descriptive term given to a pattern of skeletal malformations and cleft palate that occur in the offspring of range cows that graze certain lupine species during early pregnancy (Fig. 1).[1,2] The anomalies are characterized by the presence of limb twisting or bowing (usually the forelimbs with occasional hind-limb involvement), spinal column deviations affecting the neck and back, and other secondary skeletal defects such as rib cage deformities. Occasional cleft palate in calves is also associated with the syndrome. Cleft palate may occur with or without the skeletal malformations depending on the stage of pregnancy when the cow ingests lupine. Because the susceptible period of gestation in pregnant cows for cleft palate induction (40–50 days gestation) is very narrow, its appearance can potentially be used to retrospectively determine a timeline when cattle began to eat lupines.

Lupines are beautiful legume species that flourish in the northwestern United States (Figs. 2 and 3). There are over 500 identified species, with 150 found in the intermountain western United States and western Canada.[3] Range lupines are perennial or annual forbs found in a variety of habitats at all elevations from lowland deserts to the alpine crests. Lupine species are difficult to classify due to similar morphological (shape and size) characteristics and lack of diagnostic features. Broad geographical distribution, frequent hybridization, and habitat diversity contribute to the difficulty in accurate classification. Taxonomists, some of whom are "splitters" and others "lumpers," do not agree on many aspects of lupine classifications. Therefore, taxonomic identification of lupines suspected to cause CCS is of little use without chemical characterization. For example, seven chemotypes of *Lupinus sulphureus* (sulphur lupine) were investigated throughout its northwestern geographical distribution and four of those contained the teratogenic (malformation-causing) alkaloid anagyrine.[4] The chemotype found near Pendleton, Oregon, poses a high risk of causing CCS and was responsible for a 56% incidence in a single cow herd in the 1990s (Fig. 3).[5] A second example is a population of *Lupinus leucophyllus* (velvet lupine), also found near Pendleton, Oregon, which contains no teratogenic alkaloids and poses no risk of CCS, yet the same taxonomic species growing on the Channeled Scablands of east-central Washington contains substantial amounts of

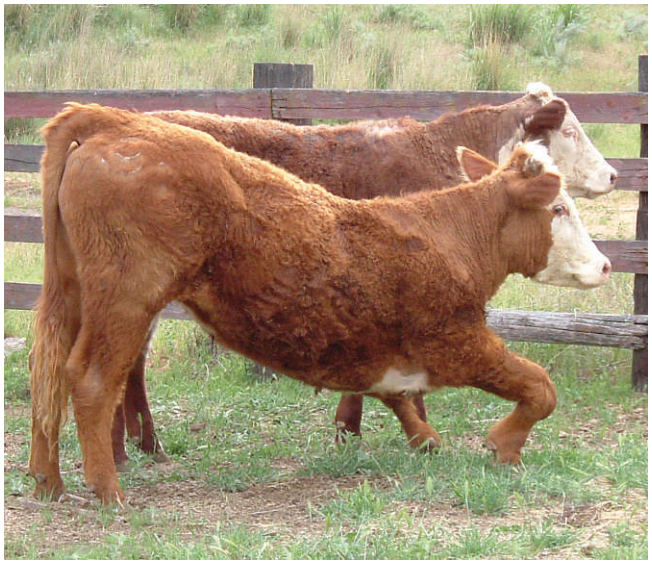

Figure 1. Yearling crooked calf salvaged for home use. As the steer continues to grow, the front legs will continue to bow and break down.

Figure 2. Velvet lupine (*Lupinus leucophyllus*) grazed by cattle in a pasture of the Channeled Scablands region of east-central Washington where crooked calf syndrome is endemic.

Figure 3. Sulphur lupine (*Lupinus sulphureus*) near Pendleton, Oregon, responsible for an outbreak of crooked calf syndrome in 1992.[5]

the teratogenic alkaloid anagyrine and is responsible for multiple outbreaks of CCS on multiple ranches including catastrophic losses in 1997 (Fig. 4). In addition to which lupine exists on any given ranch, lupine population cycles, availability of other quality forages, and grazing management practices all contribute to the incidence of CCS.

While lupines are responsible for large losses to cattle producers in the Northwest, lupines do have forage value and wild legumes are good soil stabilizers and enhance nitrogen in the soils for the other grasses and forbs. In the Channeled Scablands, lupines become an important forage source about early to mid-July when the annual grasses and forbs become mature and dry, and are of low grazing quality.[6] Table 1 summarizes the relative feed value of the forages typical for the scablands in early to mid-July. One can easily see why cattle graze velvet lupine during this period of time; if this coincides with the susceptible stage of pregnancy in cows and lupine plants are relatively abundant, the outcome is an increase in CCS.

Chemistry

Alkaloids found in the lupine family are of two classes, quinolizidine and piperidine, both of which contain toxic and teratogenic compounds. Both anagyrine (the quinolizidine alkaloid) and ammodendrine (the piperidine alkaloid) will cause CCS and both are considered diagnostic when evaluating lupine species for CCS risk. Most lupines that have been associated with CCS contain the quinolizidine alkaloid anagyrine. If both alkaloids are present, which happens occasionally, the risk of CCS is very high. If plants containing one or both of these alkaloids are grazed during the sensitive period of gestation, large losses can be expected. During the 1970s, Dr Richard Keeler (deceased) did extensive research in the Northwest on lupine species that caused large outbreaks of CCS. Through this research he identified anagyrine as the principle teratogenic alkaloid.[7] Since that time, research has shown that anagyrine is the only quinolizidine alkaloid with activity in cows and that ammodendrine occurs in relatively few lupine species.

Alkaloid concentration and chemical profiles vary widely between and within lupine species and populations. Season, year, environment, weather patterns, geographical location, and plant phenology may all influence alkaloid concentrations in plants. Recent research suggests that the alkaloid profile is relatively consistent over time and can be used as an identifying taxonomic feature[8] to differentiate lupine species and evaluate potential risk. Early-growth lupine is high in alkaloid content and potentially high risk for CCS. As the plant matures the alkaloid pool remains relatively consistent but the alkaloids are translocated to the flowers and seed pods. After seed pods shatter, the risk of lupine poisoning and CCS is virtually eliminated. This information is important in determining risk factors for CCS as the season progresses.

What is the Mechanism for CCS?

Research at the Poisonous Plant Research Laboratory (PPRL) over the last 20 years determined that the skeletal