Anagyrine in Western American Lupines

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Abstract

The teratogenic condition known as 'crooked calf disease' occurs when pregnant cows eat certain lupines with anagyrine concentrations at or above 1.44 g kg⁻¹ dry matter between the 40th and 70th day of pregnancy. Five of eight species collected in Oregon and Washington had accessions with anagyrine at or above the hazardous concentrations as determined by gas/liquid chromatography. A total of 14 species of lupine are now shown to contain accessions with potentially hazardous concentrations of anagyrine. Any range/livestock management system that will expose susceptible cattle to anagyrine-bearing lupines could result in serious calf crop losses.

Lupine species are distributed throughout the temperate regions of the world and are particularly rich in western North America. Speciation within the genus is extensive and confusing. Rydberg (1922) developed a list of 80 species in the Rocky Mountains and the adjacent plains, Tidestrom (1925) listed 53 from the Great Basin, and Hitchcock and Cronquist (1976) accepted 23 species in Washington. To further complicate species identification within the genus, Herman (1966) noted that hybridization among the species is a common occurrence.

Lupines have been considered good to poor feed, depending on their toxic principals, season of use, and class of livestock (Herman 1966). They have been shown to be a common source of the apparently teratogenic alkaloid anagyrine (Keeler 1976) and the extent of its occurrence is only partially understood. At least 9 species are reported to contain anagyrine in concentrations high enough to cause crooked calf disease (Davis 1982). The true extent of the teratogenic potential of this genus will not be known until the lupine species and ecotypes are more completely collected and analyzed. This study was undertaken to further the understanding of the probable teratogen anagyrine in the native western American lupines.

Materials and Methods

The collection of native lupines (Tables 1 and 2) represents the native species commonly found in the rangelands of the Pacific Northwest. The procedures for field grown lupines were the same in this experiment as were employed by Davis (1982) and are not repeated here. This collection has been catalogued and entered in the USDA Plant Introduction system and seeds of all accessions compared to the concentrations of sparteine, lupinine, and lupanine. Burke's lupine ranked second only to the silvery lupine. Anagyrine may be considered a minor alkaloid in most species when compared to the concentrations of sparteine, lupinine, and lupanine. These and other lupine alkaloids are responsible for the classic symptoms of lupine poisoning or toxicosis (Anon. 1968). The average highest total alkaloid concentration was found in silvery lupine, with a range of 11.4 to 50.2 g kg⁻¹. In contrast, the anagyrine content of spurred lupine, was only 0.1 g kg⁻¹ in the 2 collections that had detectable levels, but total alkaloid varied from 8 to 25 g kg⁻¹. The dry ground lupine, a low growing, mound-like, almost stemless lupine, was low in total alkaloids with a range of 4.2 to 18 g kg⁻¹ and no anagyrine was found. This species is morphologically similar to the prairie lupine, a recognized poisonous species, and is considered by some botanists to be a subspecies of the prairie lupine. Burke's lupine had anagyrine in 3 of the 4 accessions, but only 1 of these was high enough to be potentially teratogenic. Burke's lupine ranked second only to the silvery lupine in total alkaloids.

The tailed lupine was the only species in which all of the accessions had anagyrine concentrations at or above the minimum teratogenic level of 1.44 g kg⁻¹. These concentrations verify the teratogenicity of this species as reported by Keeler (1976). Total alkaloids ranged from 6-12 g kg⁻¹ with anagyrine the principal alkaloid in this species, averaging 33.5% of the total alkaloid content. Other teratogenic lupines were the silky lupine, the velvet lupine, and the seashore lupine.

Lupine species collected from Montana, Idaho, California, Oregon, and Washington were grown in the greenhouse and alkaloid levels are presented in Table 2. Eleven species were found to have accessions with anagyrine levels above the critical concentration of 1.44 g kg⁻¹. None of the annual species were found to contain anagyrine at teratogenic levels.

The cultivar 'Hedera' (sickle-keeled or pine lupine) is the only developed agronomic cultivar of a native western lupine. Ornamental cultivars have been bred from the Washington lupine, (Kelsey and Dayton 1942) and have been used for green manure in Europe. 'Hedera' has been fed to cattle and sheep with no teratogenic effects (James 1976). Foliage of 'Hedera' has been analyzed by the author and no anagyrine was found, but high concentrations of total alkaloids were present. By comparison 2 of the 3 wild collected accessions of sickle-keeled or pine lupine showed concen-
trations of anagyrine in the teratogenic range. The single collection of Anderson’s lupine was average in total alkaloids and had anagyrine concentrations well above the teratogenic minimum. The broadleaf lupine was above average in total alkaloids and had anagyrine concentrations similar to the Washington lupine and the silky lupine. The species with anagyrine at the highest concentration was the Mt. Rose lupine with anagyrine at 10.27 g kg⁻¹ and a total alkaloid concentration of 19.14 g kg⁻¹.

Based on these and previous findings of Davis (1982), the following species have produced accessions with anagyrine levels that are potentially teratogenic; the pine or sickle-keeled lupine, the mountain silvery lupine, Anderson’s lupine, the silvery lupine, Burke’s lupine, the silky lupine, the broadleaf lupine, the seashore lupine, the velvet lupine, the Mt. Rose lupine, the Washington lupine, and the silky lupine. This brings to 14 the known species with anagyrine at teratogenic concentrations. This number is variable depending on the system of speciation used and the synonymy that is present in the literature.

With the development of ‘Hederma’ as an anagyrine-free cultivar of the pine or sickle-keeled lupine, it follows that anagyrine-free cultivar development in other species should be possible. Concurrently the total alkaloids could be reduced and the palatability and forage quality should be improved. With extensive screening of widely collected germplasm, followed by intensive selection and breeding, accessions and possible new cultivars free of anagyrine with low total alkaloid content could be developed. They could be valuable additions to seeding mixtures where revegetation of depleted ranges is required. They could provide both forage and a nitrogen source to the range forage plant community.

References
Anonymous. 1968. 22 plants poisonous to livestock in the Western States. USDA Information Bulletin 327.

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