INFLUENCE OF ALKALOID CONCENTRATION ON ACCEPTABILITY OF TALL LARKSPUR (Delphinium spp.) TO CATTLE AND SHEEP

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Abstract—Tall larkspur (Delphinium spp.) is a serious toxic plant problem on western U.S. ranges. The major toxins in tall larkspur are methyllycaconitine (MLA) and 14-deacetylnudicauline (14-DAN); the sum of both is termed the toxic alkaloid concentration. Toxic alkaloids comprise about 20-50% of the total alkaloid concentration in tall larkspur. Toxic and total alkaloid concentration generally declines with maturity, whereas cattle and sheep consumption of larkspur typically increases with plant maturity. We hypothesized that cattle and sheep consumption of tall larkspur was negatively related to higher concentrations of total or toxic alkaloid. We compared consumption of several collections of dried, ground larkspur and fresh larkspur in a series of trials. In another trial, a crude alkaloid fraction was extracted with ethanol, added to alfalfa hay, and consumption compared to untreated alfalfa hay, alcohol-treated hay, and the essentially alkaloid-free plant residue. In all cases we correlated amounts eaten with total and toxic alkaloid concentration. A grazing trial was also conducted to relate larkspur consumption over time to alkaloid concentrations. Total alkaloid concentrations in dried, whole-plant collections ranged from 9.3 to 38.8 mg/g of dry weight, whereas toxic alkaloid concentrations varied from 0.0 to 7.1 mg/g. In one pen trial, cattle preferred a larkspur collection (P < 0.01) that contained no toxic alkaloids but had a high total alkaloid concentration (39 mg/g). There was no correlation (P > 0.05), however, between concentrations of total or toxic alkaloids and amount of dry plant consumed in this or any other trial. Conversely, sheep consumption tended to be negatively influenced by total and toxic alkaloid concentration (P ≤ 0.08). In the trials with extract, cattle preferred the alcohol-treated hay and rejected the alkaloid-free residue (P < 0.01), whereas the alkaloid-

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treated hay was of intermediate acceptability. Cattle preferred the alkaloid-treated hay over the alkaloid-free residue, indicating that alkaloids did not deter consumption. Conversely, the alkaloid-treated hay was less preferred than either untreated or alcohol-treated hay, suggesting a negative effect on acceptability. There was no correlation between alkaloid concentration and amount of treated feed eaten. In field trials, the amount of compositing, fresh leaves or flowers eaten by cattle was influenced by plant part \( (P = 0.04) \), but was not related \( (P > 0.05) \) to alkaloid concentration. Cattle preferred leaves over flowers when offered individual plants differing in phenological stage and/or amount of shade, but alkaloid concentration was not related to consumption. We conclude that knowledge of the concentration of total or toxic alkaloid in tall larkspur will give little or no indication of plant acceptability to cattle. Even though accurate predictions can be made about the potential toxicity of larkspur based on the concentration of toxic alkaloids, predictions about consumption must be based primarily on plant phenology.

**Key Words**—Plant toxins, palatability, diterpenoid alkaloids, methyllycaconitine, *Delphinium* spp.

**INTRODUCTION**

Tall larkspur (*Delphinium* spp.) is a serious toxic plant problem on western U.S. ranges. Cattle grazing summer ranges sometimes consume large quantities (>30% of diets) of tall larkspur (Pfister et al., 1988a,b) and are often fatally poisoned as a result. Death losses average 5% and may exceed 15% each year on grazing allotments where larkspur is prevalent.

The major toxins in tall larkspur are the diterpenoid alkaloids methyllycaconitine (MLA) and 14-deacetyl nudicauline (14-DAN) (Manner et al., 1993). Collectively, these two alkaloids account for about 90% of the toxicity of tall larkspur (Manners and Panter, unpublished data, 1995). These toxins block acetylcholine receptors in the central and peripheral nervous systems, resulting in muscular paralysis and eventually death (Dobelis et al., 1993). Tall larkspur contains other diterpenoid alkaloids in varying quantities (e.g., delta-line), but these other alkaloids are relatively nontoxic (Manners et al., 1993). Thus, in examining the alkaloid concentration of MLA and 14-DAN, the sum of these two toxic alkaloids (MLA + 14-DAN) are termed the toxic alkaloid concentration, and the combined concentration of all alkaloids are the total alkaloids.

The toxic and total alkaloid concentration in leaves generally declines as plants mature (Ralphs et al. 1988; Pfister et al., 1994a), whereas cattle and sheep consumption usually increases with plant maturity (Pfister et al., 1988a,b; Pfister and Manners, 1991, 1995; Ralphs et al., 1991; Ralphs and Olsen, 1992). Based on this inverse relationship, we hypothesized that toxic or total alkaloid concentration negatively influences the acceptability of tall larkspur to cattle and sheep. Our objective in this study was to test this hypothesis using both dried and fresh tall larkspur plant in a series of pen and field trials.