

Larkspur (Delphinium species)



Larkspurs: Extent of the Problem

- **Marsh (1913) stated that larkspurs kill more cattle on western ranges than any other plant (locoweed excepted)**
- **Tall larkspurs- serious problem on mountain rangelands**
- **Low larkspurs- problematic on foothill and mountain ranges.**
- **Plains larkspur- persistent problem on High Plains (particularly Wyoming & Colorado)**

Identifying larkspurs- note spur on the flowers



Delphinium (Larkspurs)

- Diverse group
- Divided into three categories:
 - tall (*barbeyi*, *occidentale*)
 - low (*nuttallianum*, *andersonii*, *bicolor*)
 - plains (*geyeri*)
- Cause \$6-10 million in losses annually



Various Larkspur Types



- Tall larkspurs - grow 3-6 ft. tall
- Low larkspurs - few fine stems and grow 8-24 in. tall
- Plains larkspur - intermediate type that reaches 24-36 in. tall

Low Larkspurs



- **Grow early in spring on foothill and mountain ranges with adequate spring moisture - 3,000 to 9,000 ft. elevation**
- **Depending on moisture and temps, may persist for 6 weeks or so**
- **Density influenced by spring moisture; lower density usually means fewer losses**

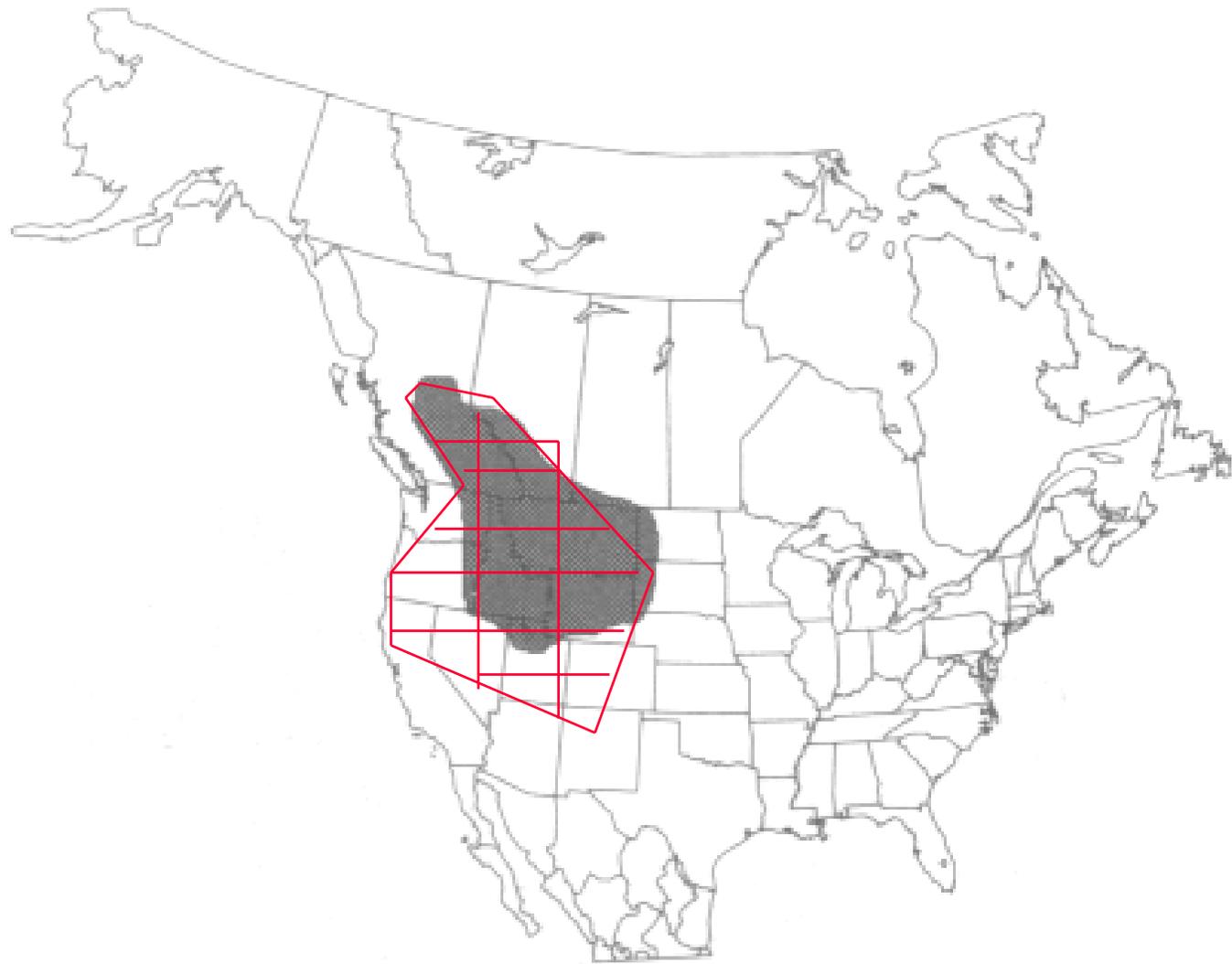
Tall larkspurs

- **Tall larkspurs: found in mountain habitat in the western U.S. - generally moist sites - 6,000 to 10,000 feet elevation**
- **Tall larkspur sites typically snow-covered during winter**
- **Tall larkspurs grow in forb-dominated sites; very nutritious forage and high carrying capacity**

Tall larkspur distribution



	<i>D. barbeyi</i>		<i>D. glaucescens</i>
	<i>D. glaucum</i>		<i>D. occidentale</i>



Delphinium bicolor

nuttallianum



Delphinium andersonii



Delphinium bicolor

Distribution of plains larkspur



Delphinium geyeri

How does tall larkspur grow?

- Old growth dies back in fall
- During winter new buds from root crown can grow under snow
- New stems may penetrate over 6 inches of snow to reach sunlight



How does tall larkspur grow?



- New emergent stems are among first plants to come up from under melting spring snow

How does tall larkspur grow?

- Stems grow from root crown
- Buds form in clusters
- As stems elongate, flowers appear but are closed
- Flowers then open
- Pods begin forming



How does tall larkspur grow?

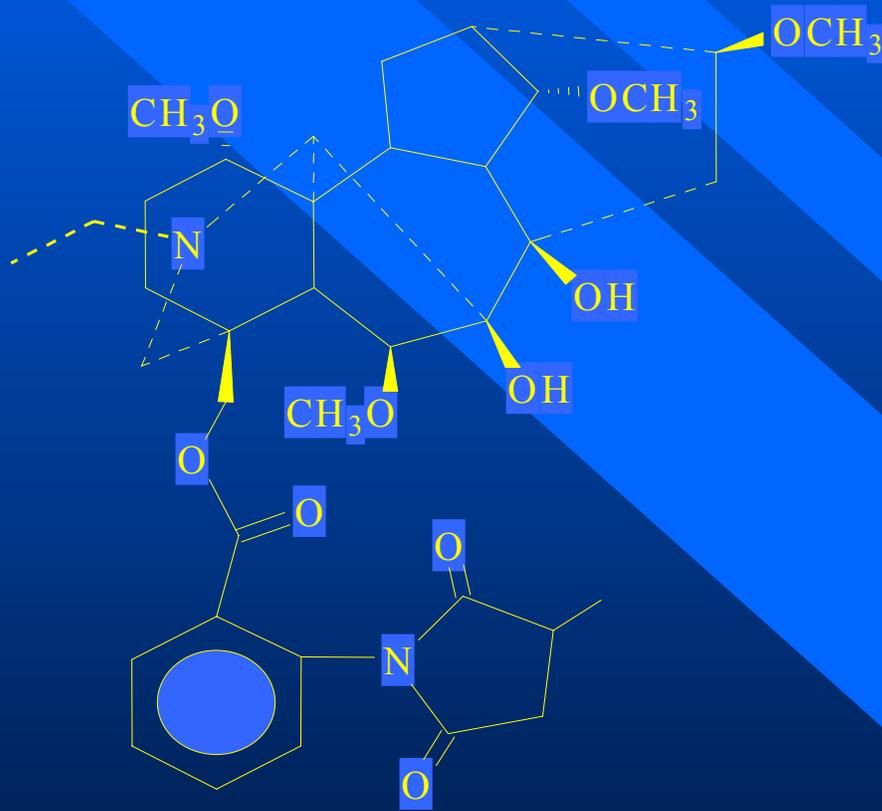
- Tall larkspurs emerge in some times dense patches from receding snow banks



Larkspurs are among the first plants to emerge in spring



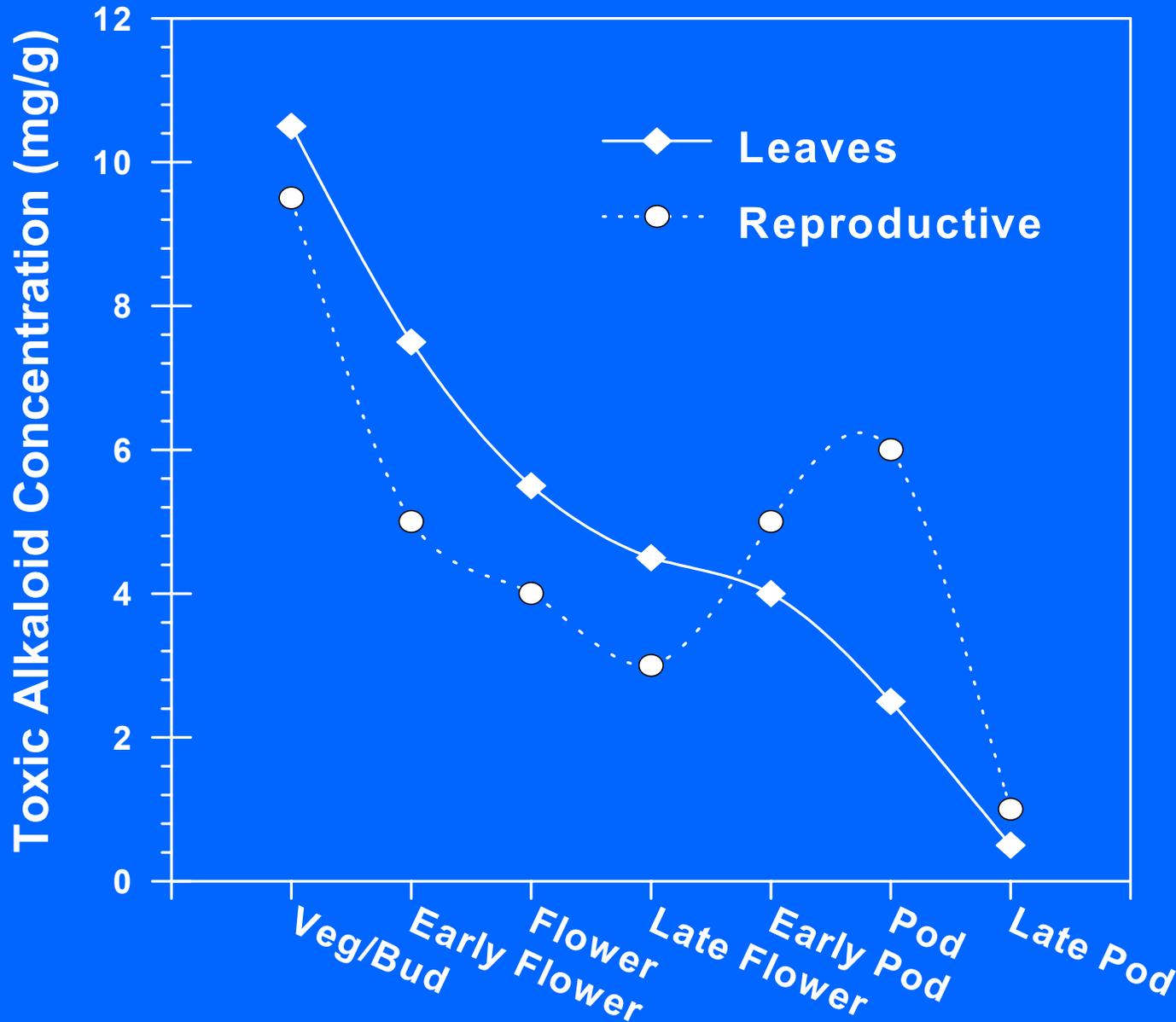
Dominant toxic alkaloid in larkspurs



Methyllaconitine

- There are numerous diterpenoid alkaloids in larkspurs (> 20)
- Ester function at C18 is v. important for toxicity
- Deltaline most common alkaloid in tall larkspurs but not v. toxic
- Methyllaconitine = MLA

Seasonal Change in Toxicity



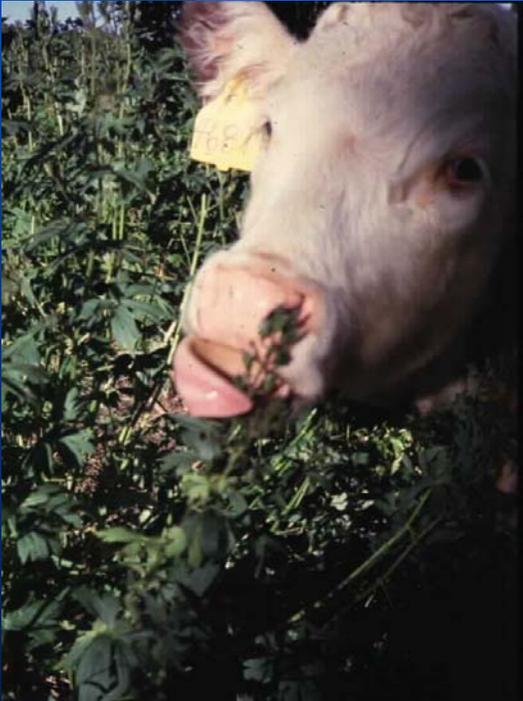
< 3 mg/g - low

3-6 mg/g - moderate

> 6 mg/g - high

How Does Larkspur Kill cows?

Answer: Neuromuscular paralysis

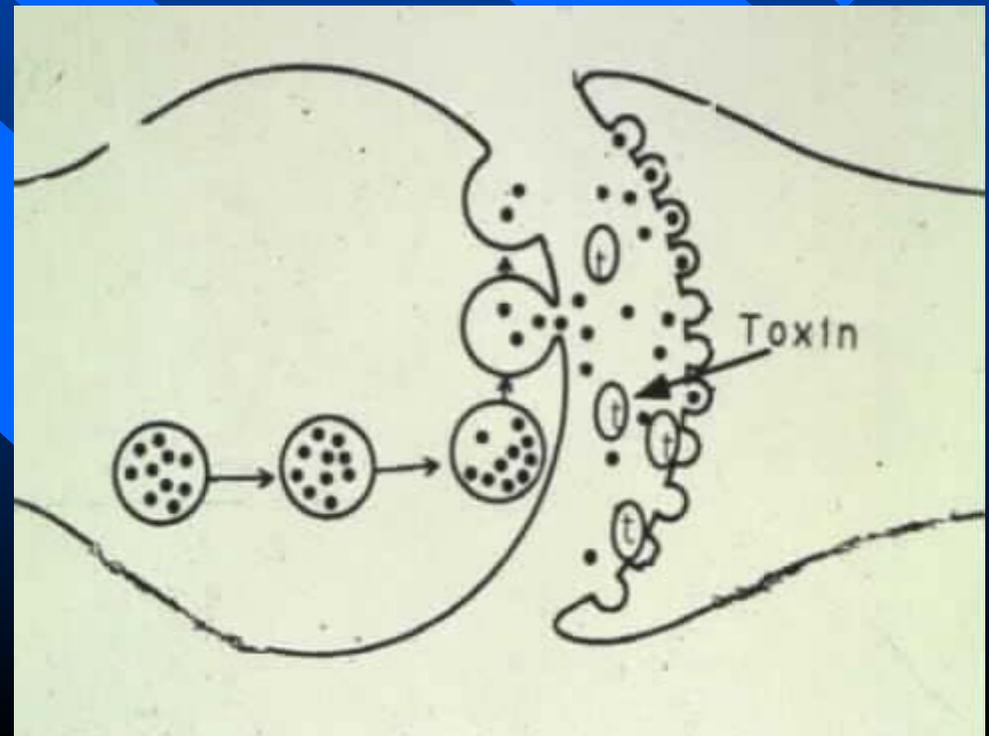


Clinical signs of larkspur poisoning

- **Staggering gait**
- **Muscular trembles**
- **Periodic sternal then lateral recumbency (this can lead to death for various reasons)**
- **Difficulty breathing (rapid and shallow)**
- **Death occurs from respiratory paralysis and/or bloat**
- **Bloat may cause fatalities alone even if animal did not eat a fatal dose of larkspur**

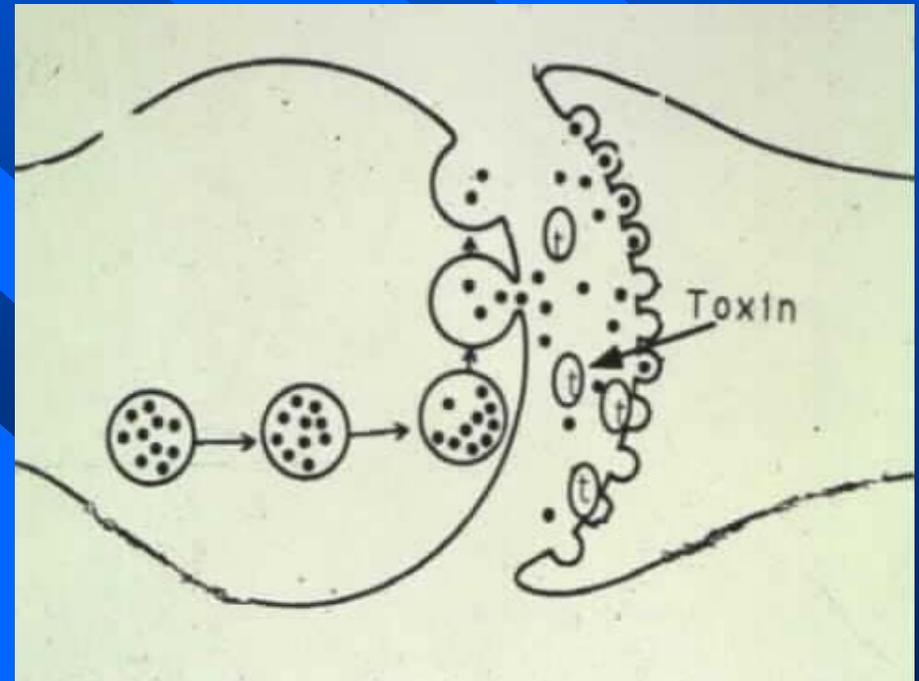
Mechanism of Action

- Curare-like action
- Reversibly binds to nACh postsynaptic receptor sites



Mechanism of Action

- When Ach receptors are bound by MLA at neuromuscular junction, then electrical stimulus that tells muscle to contract is blocked
- Affects leg and diaphragm muscles (trembling, weakened respiration and ability to stand, then death)

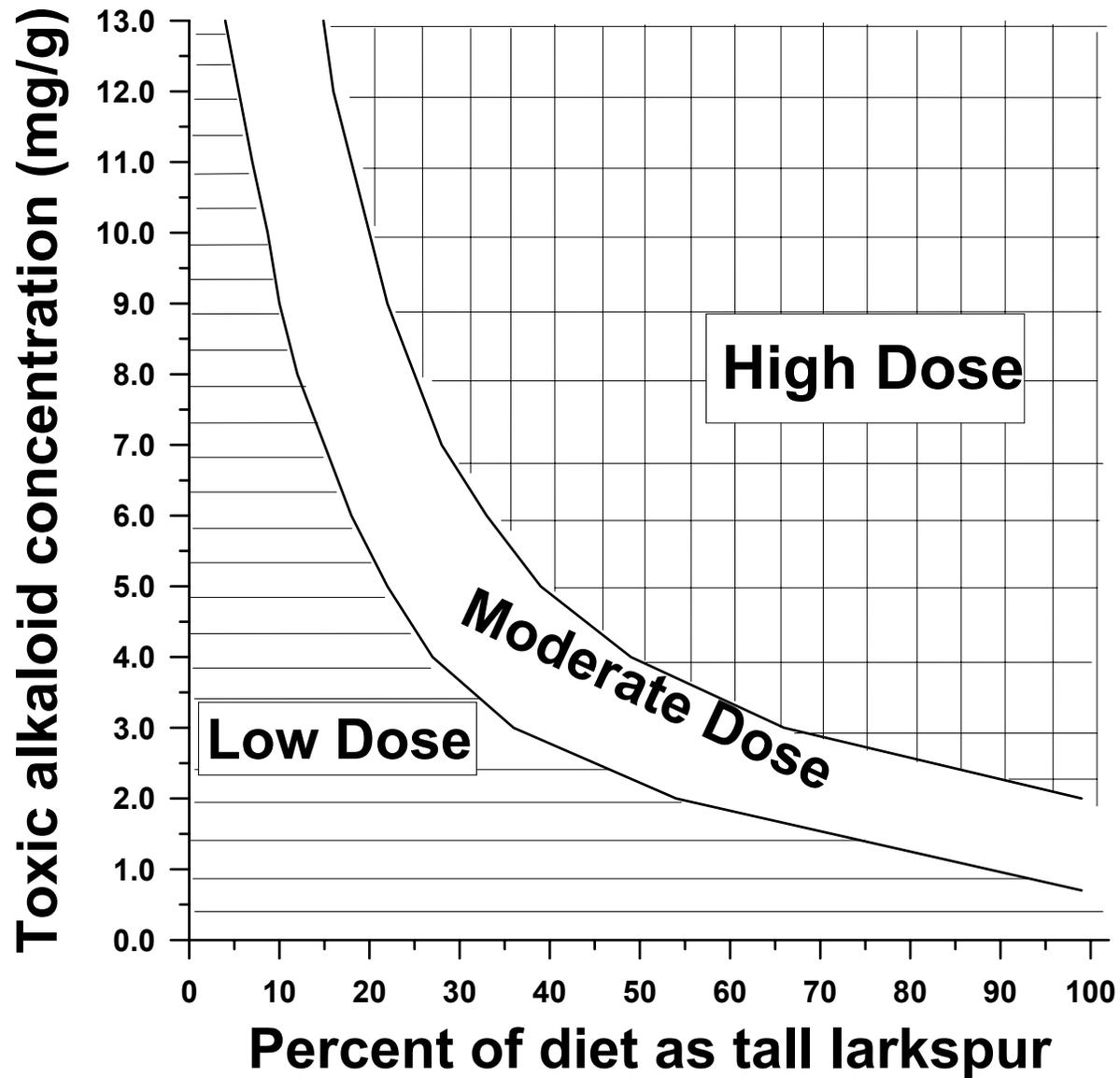


Why doesn't Larkspur kill sheep?



- Sheep must eat 4-5 x as much larkspur to show effects compared to cattle
- Rumen metabolism?
Probably not.
- Binding affinity of MLA at neuromuscular junction?
Probably reason for low susceptibility.

How much larkspur does it take to kill cows?

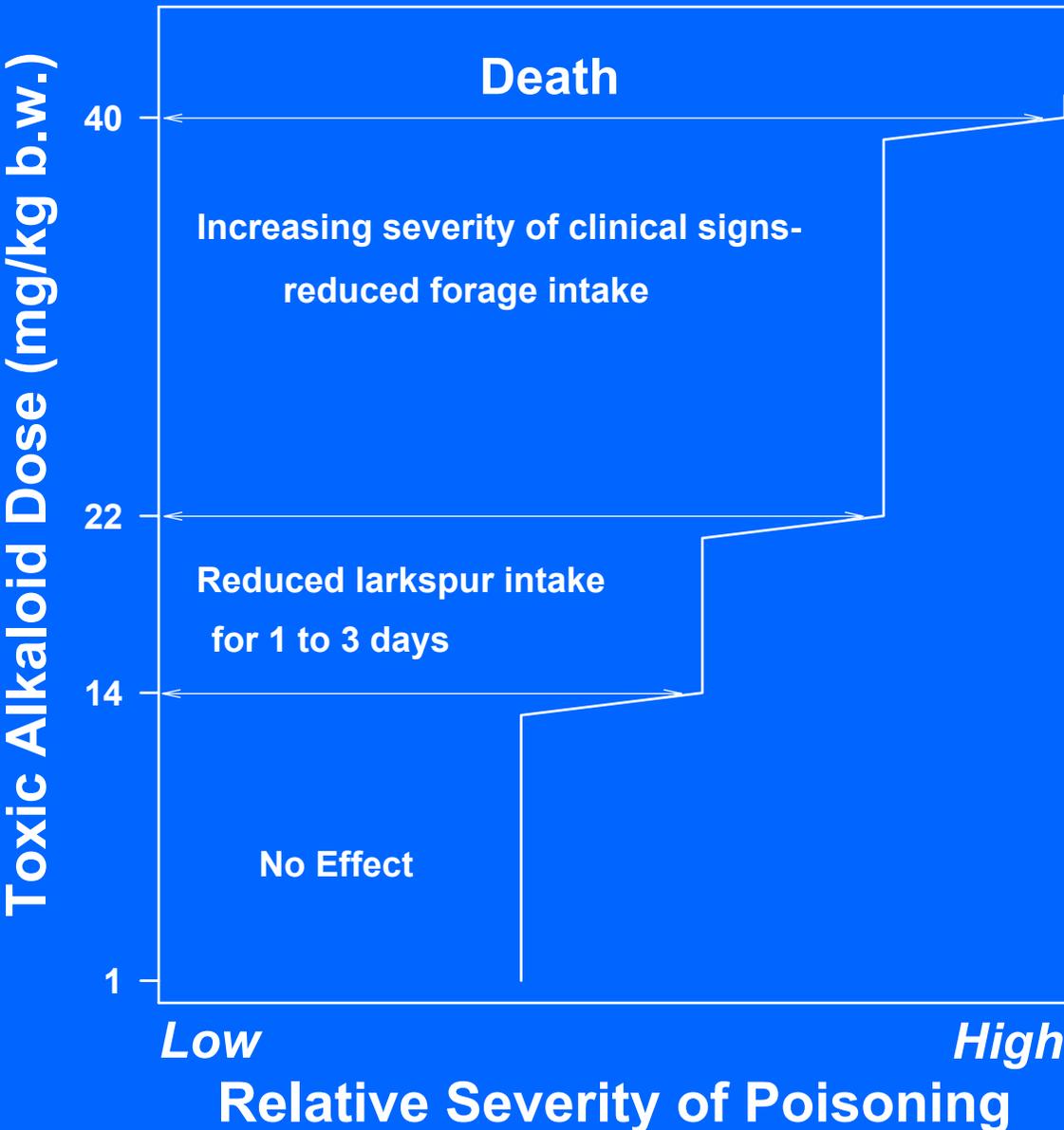


Doses of larkspur that impair and kill cattle



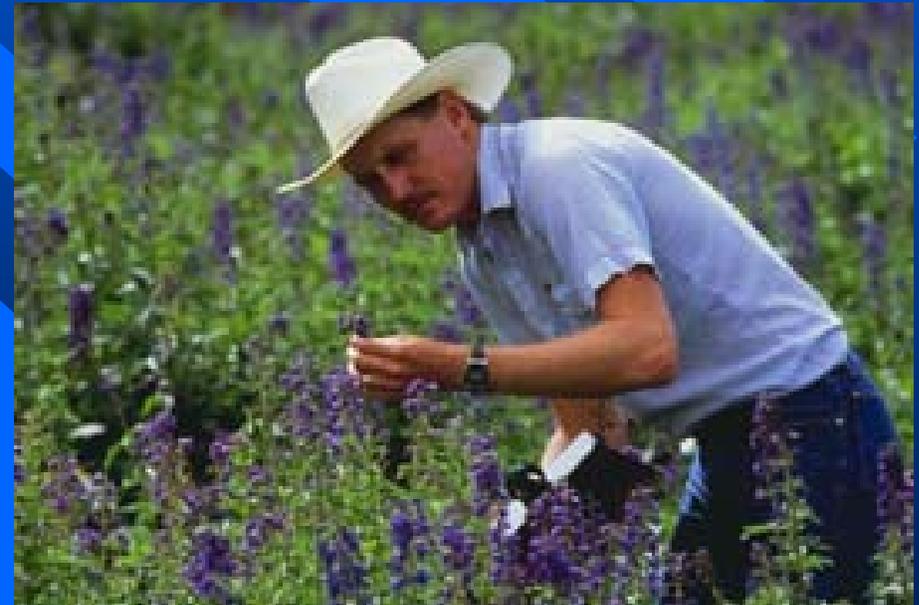
- Effective dose - causes tremors & temporary sternal recumbency
- Dose of 18-20 mg/kg of MLA (as plant material)
- MLA @ 5 mg/g then need to eat ~ 1.8 kg dry wgt (7.2 kg fresh wgt) for 450 kg cow
- Lethal dose about 30-40 mg MLA/kg b.w.

Three Thresholds in Tall Larkspur Toxicosis

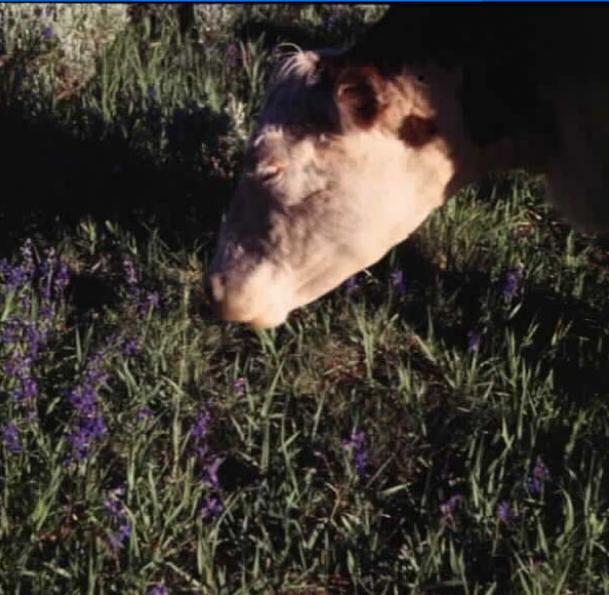


Key aspects of ingestion and toxicity

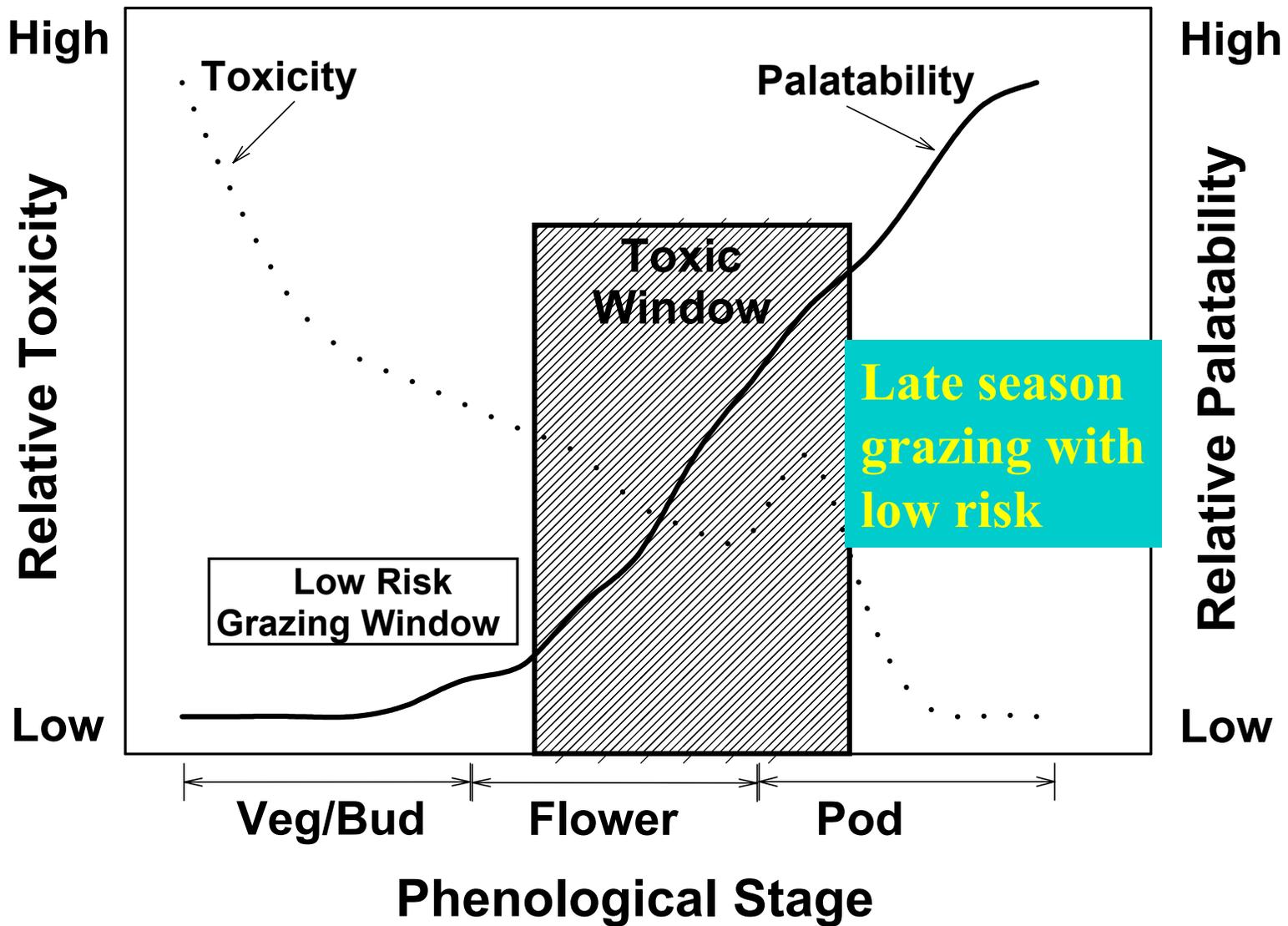
- First, amount of larkspur eaten
- Second, rate of ingestion
- Third, toxicity of larkspur
- Fourth, how many consecutive days larkspur is eaten in substantial quantities

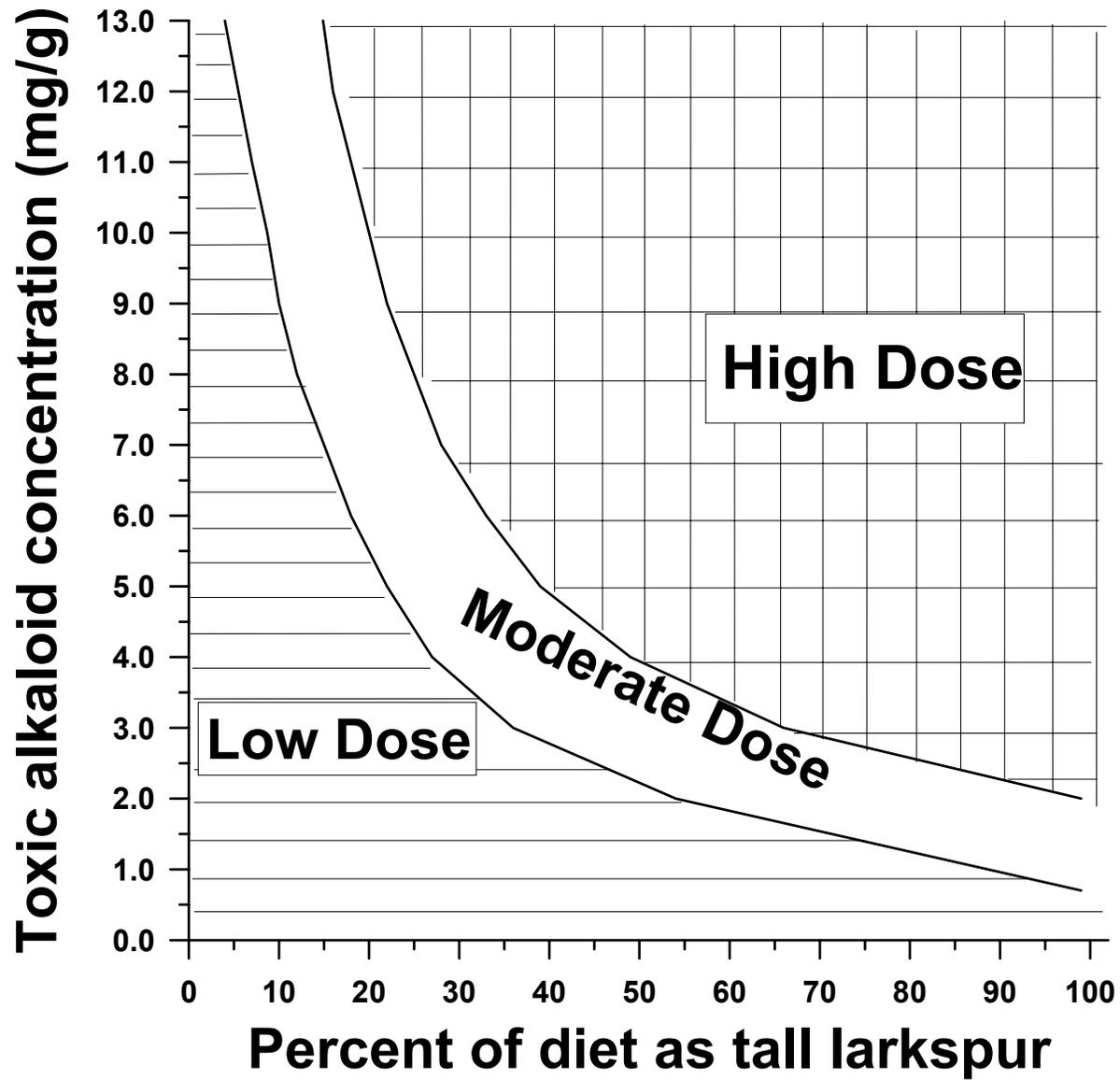


When and how much larkspur do cows eat?



- Cattle eat little or no larkspur before larkspur elongates flowering racemes
- After flowering, if cattle eat larkspur, then consumption usually increases greatly during late flower and pod stages
- Traditional grazing mgt: put cows into larkspur (poison) pastures after larkspur flowers.





Larkspur: Effects on Nutrition



- **Nutritious plant with no adverse nutritional effects**
 - 14% CP, 30% NDF
- **Low (chronic or sublethal) levels have positive aspects with no toxicity**
- **Cattle eat more larkspur with increasing levels of rumen fill**

Preventative Measures

- **Grazing management**
- **Conditioned aversions**
- **Sheep grazing**
- **Herbicidal control**
- **Drug therapy**
- **Vaccination ?**
- **Bloat Prevention?**
- **Mirid (insect biocontrol)?**



Larkspur Grazing Management

Low Larkspurs

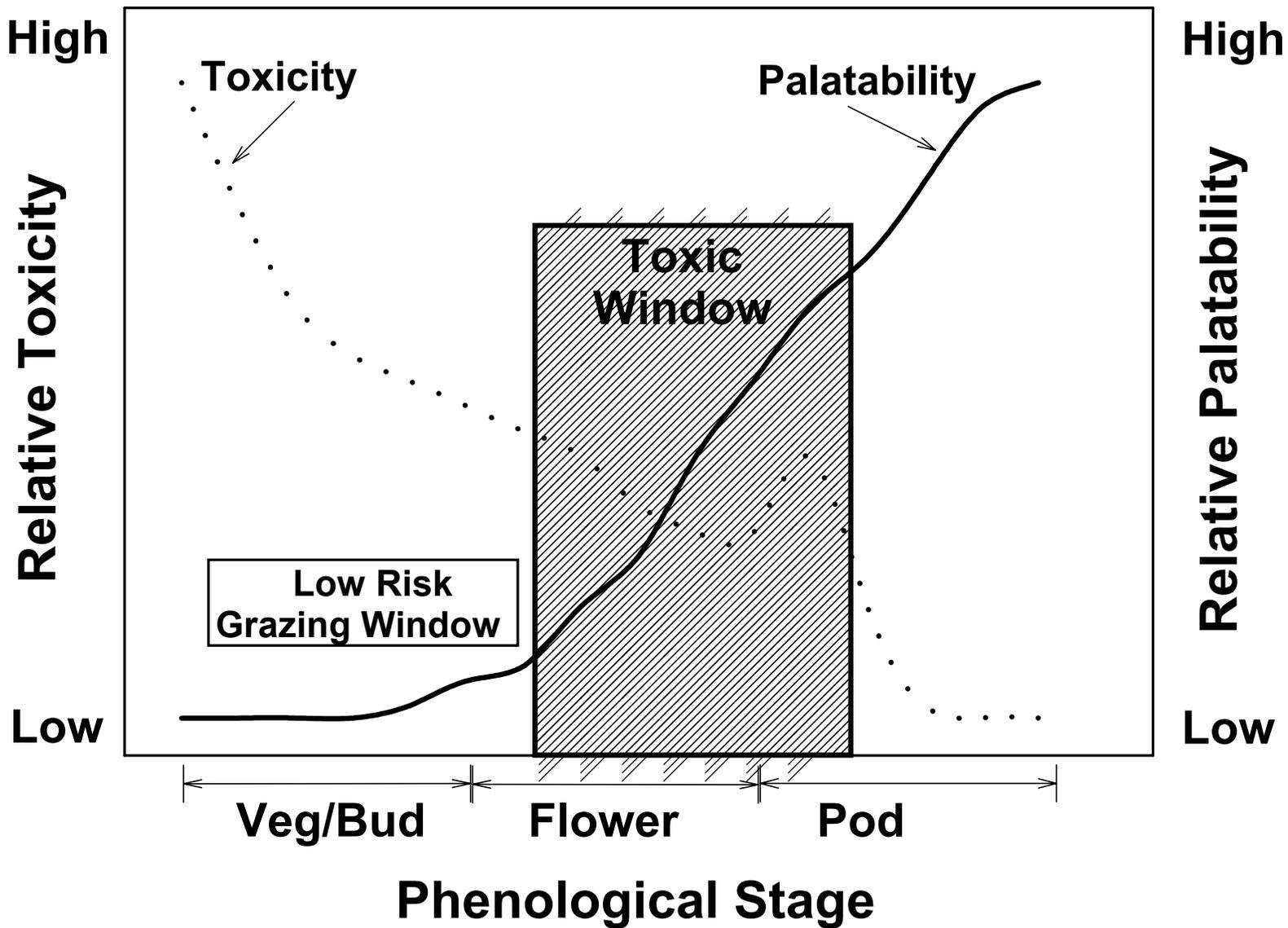
- Contain toxins not found in tall larkspurs
- Toxicity relatively stable over time
- Cattle eat most after flowering
- Even dry stems may be toxic, but cattle have difficulty eating enough after pods shatter



Plains larkspurs (*D. geyeri*)

- Emerges early in spring before grasses
- In 3 of 4 grazing studies, cows ate little *geyeri*
- In 1 study, consumption began when plant was in early flower stage
- Intoxicated cows ate in cyclic fashion (2-3 days up & down)





Proper Distribution (Herding)



- Use rider to sample larkspur
- Use rider to observe cows
- Use rider to keep cows from dense patches
- Use rider to move cows to new forage

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Averting cattle to larkspur

- **Drug (LiCl @ 200 mg/kg) causing nausea paired with flavor of larkspur**
- **Cattle associate taste of larkspur with gastrointestinal distress from LiCl**
- **Pros: aversion reasonably easy to condition; 1 or 2 doses avert cattle for at least 3 yrs**
- **Cons: Social facilitation may extinguish; intensive management option (I.e., handling livestock); each dose of LiCl costs \$6.00**

Averting cows to larkspur: a case study

- 300 cow operation; 150 cow stocking rate
- Losses of 5-15% each year

	<u>Cows averted</u>	<u>Cows eating</u>	<u>No. Dead</u>
■ 1997	45	16	1
■ 1998	59	8	0
■ 1999	45	0	0

Cows averted previous year put back in subsequent years.
All cows familiar with larkspur.

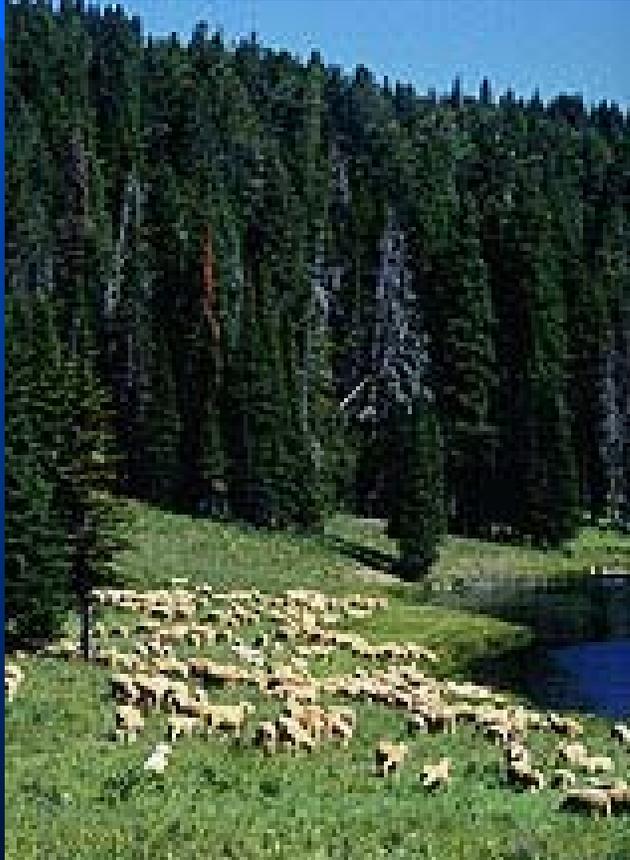
Use rider to watch cows; remove eaters; move to fresh feed.

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Sheep Grazing Before Cattle



- **Sheep very tolerant**
- **Need to graze larkspur early to do much good**
- **Must not eat all other forage**
- **Bedding or trailing over dense patches some times works well**

Preventative Measures

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- **Herbicidal control**
- **Drug therapy**
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Herbicidal Control of Tall Larkspurs

- Must penetrate waxy leaves, kill root crown
- Herbicides: Escort @ 2 oz ai/acre -vegetative
- Tordon@1-2 lb ae/acre bud/flower stage
- Treatments good for 20 years
- Dead plants are palatable and very toxic so no grazing that year



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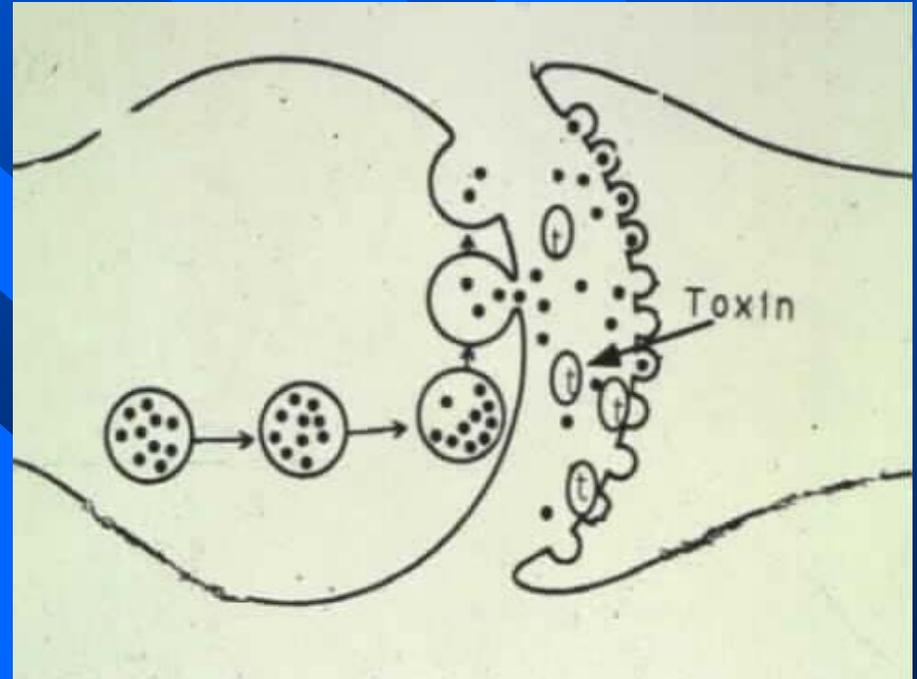


Drug Therapy

- **MLA blocks Ach receptors, therefore drugs that inhibit the enzyme acetylcholinesterase in the synapse should be effective in treating poisoned animals**
- **Early larkspur researchers used a cocktail of physostigmine, strychnine, and atropine to treat afflicted animals. Pharmacy in Wyoming still sells the cocktail (\$30/3 dose vial).**
- **We have tested physostigmine at 0.08 mg/kg b.w. and found it to be effective if given I.V.**

Rational Drug Therapy

- Acetylcholinesterase breaks down Ach in the synapse
- If this enzyme is inhibited, then Ach concentrations can rise dramatically
- This allows the Ach molecules to compete more effectively for binding sites on the muscle, thus greatly reducing the effect of the toxin



Drug Therapy (Pro and Con)

- **Pro - Ranchers can save some animals that might die otherwise**
- **Pro- Drug is relatively inexpensive and easy to administer**
- **Con - V. difficult to observe most animals, so most are dead when found**
- **Con - Giving drug may make situation worse if animals (less than lethal dose) become ambulatory then get excessively fatigued**

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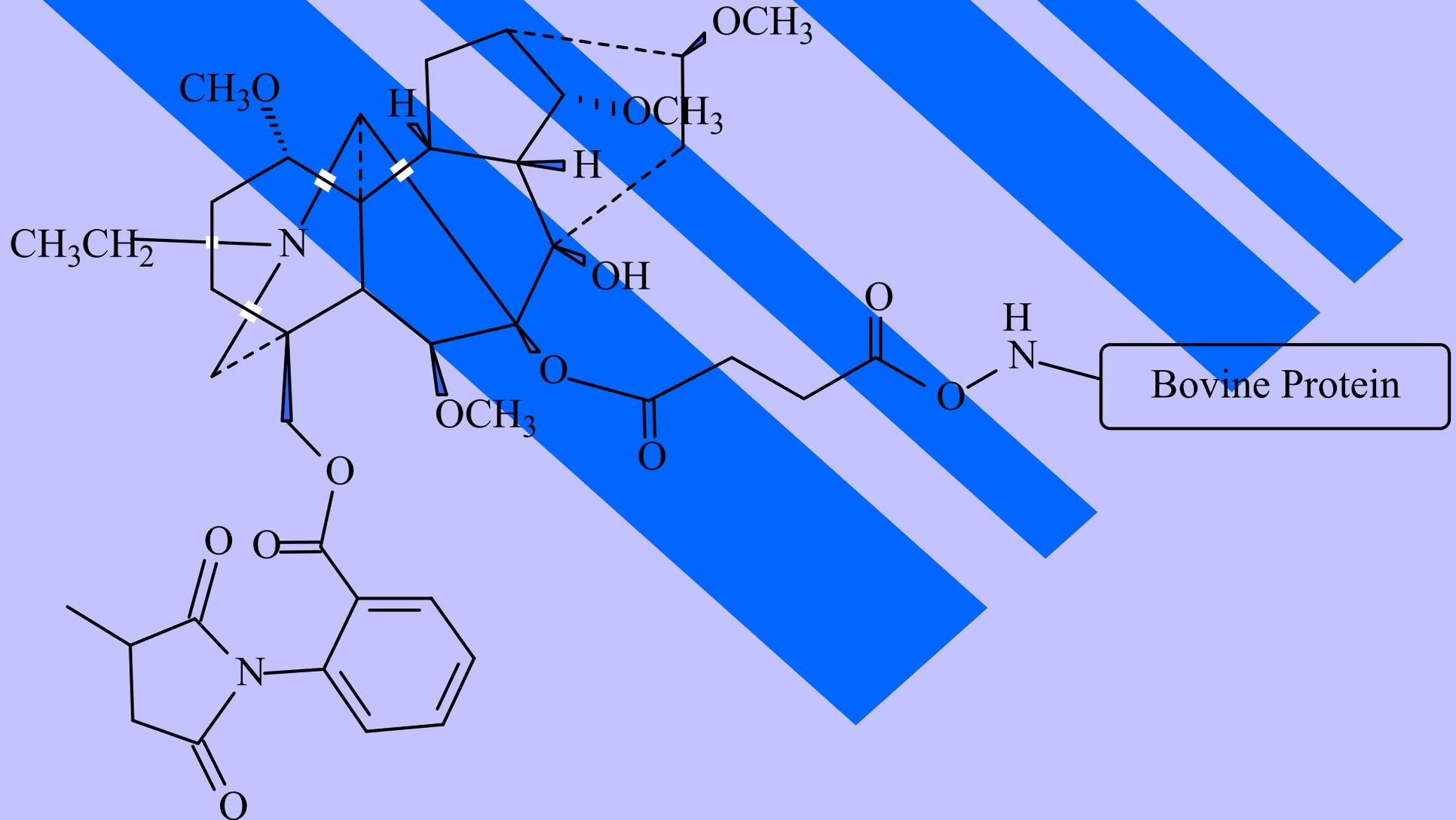


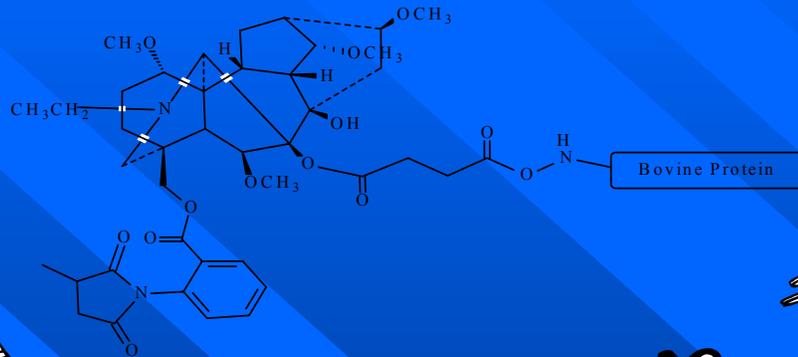
Vaccines to Prevent Larkspur Deaths

- **Theory: Immunogenic molecules trigger an immune response and interact with antibodies. Must be:**
 - high molecular weight (> 1000)
 - foreign, not native
 - chemical complexity
- **Larkspur toxins are used to make conjugates**
- **Conjugates have immunogenic properties (promote antibody formation)**
- **Must be specific for toxin and related compounds**



ELISA and Vaccines for Larkspur





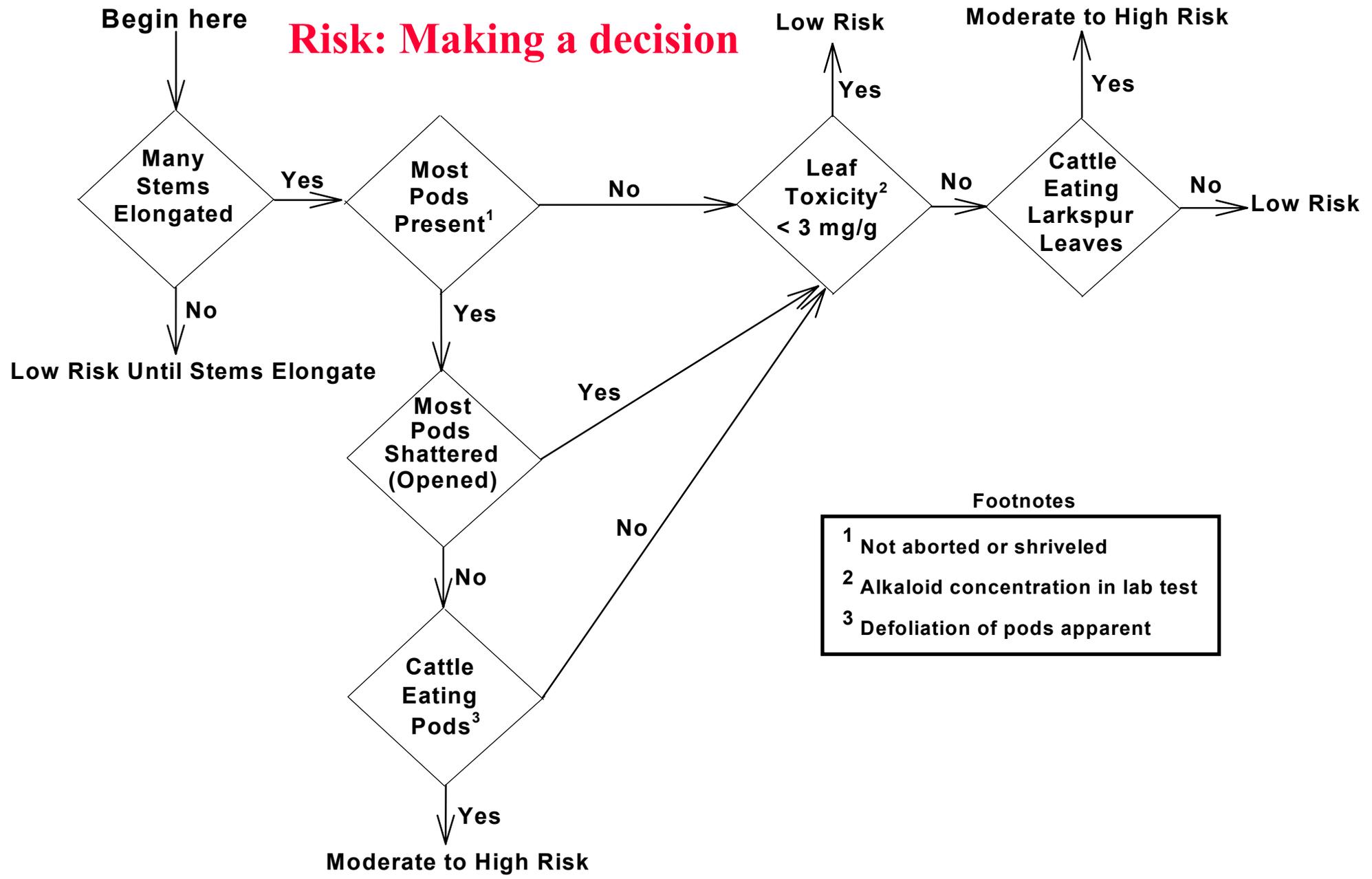
Sheep developed titers (antibodies) to conjugates; mice injected with conjugates - those that developed higher titers showed higher survival when challenged with toxic doses of MLA

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Risk: Making a decision



Footnotes

- 1 Not aborted or shriveled
- 2 Alkaloid concentration in lab test
- 3 Defoliation of pods apparent

Larkspur: Current Recommendations

- Risk assessment- Collect larkspur & observe cow behavior
- Graze early; graze late and avoid toxic window
- Create larkspur-free areas if possible w/ herbicides
- Use aversive conditioning
- Use rider to redistribute animals as needed



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